

RICE UNIVERSITY

**Rural Datascares:
A Data Farm Network for Rural North Dakota**

by

Sara DeeAnn Hieb

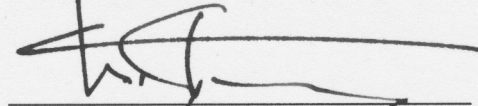
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Master of Architecture

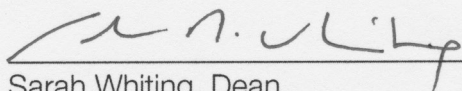
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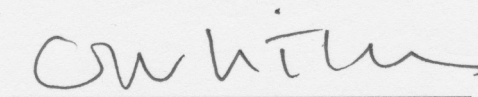
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ABSTRACT

Rural Datascape: A Data Farm Network for Rural North Dakota

by

Sara Hieb

This thesis attempts to render architectural agency and aesthetics within the typological discussion of the data center and its placement in the rural American landscape. The disciplinary question of the role of architecture and aesthetics in data center design is related to earlier examples of factories and warehouses during modernity. The data center alters the traditional representative role of architecture; they are massive, horizontal buildings that are only conceivable from an aerial perspective, driven by logistics and efficiency. This thesis engages these issues by focusing on the point at which the architectural and programmatic problems of the data center converge, the building form and envelope. This thesis engages the building envelope as an expanded surface that considers not only logistical and environmental issues, but also engages the social and political architectural questions related to the identity of the data center in the rural landscape.

Acknowledgements

It is a pleasure to thank the many people who made this thesis and Master of Architecture degree possible. Firstly, I would like to extend gratitude to Hyun-Tae Jung and Doug Jackson, both of whom have been indispensable to my education, intellectual growth, and guidance in the pursuit of graduate school, in addition to Patricia Morgado and Jeff Day.

I cannot overstate my gratitude towards Christopher Hight, my thesis advisor, for his unwavering guidance and efforts. He provided me with enthusiasm, criticality, and ideas, in addition to pushing my critical thinking skills and design abilities. He was a great leader and was a huge reason why I had an enjoyable thesis experience that led to my own intellectual discoveries. I would also like to thank Scott Colman, Albert Pope, and Sarah Whiting for their leadership during the pre-thesis semester and beyond, in addition to all other RSA faculty who have provided feedback and advice throughout the thesis process. Overall, I would like to thank the RSA community for all the intellectual support and opportunity I have been provided with throughout my graduate education. I also want to thank those who established the John Crowder Traveling Fellowship, which made the travel and research for my thesis project possible.

I would like to thank my closest friends and colleagues Jason Minter, Cristina Lorie, and Brittany McClure, from undergrad, in addition to my closest friend from graduate school, Sue Biolsi, as well as Kelly Barlow and Sean Kizy. All of these people have provided me with camaraderie, academic and emotional support. I respect all of them for their intellectual curiosity, in addition to the fact that they are simply good people.

I would also like to thank the group of people who helped me tie up loose ends of my project during production. It wouldn't have been possible without them. Thank you to Ying Tao, Vy Drouin-Le, Maia Simon, Kelsey Olafson, Brittany McClure, and David Richmond for all of their help and support.

I want to thank my fiancé Michael Lum for his loving support from 900 miles away in Nebraska, in addition to the love from my little sister, Laura. I also feel grateful for my loving extended family living in Texas, especially my Aunt, Wendy Wilslef.

Lastly, but most importantly, I wish to thank my parents, Michael and Valerie Hieb, both of whom have worked hard for absolutely everything and given me every opportunity in life.

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Figure 1

"Landscape is not scenery, it is not a political unit, it is really no more than a collection, a system of men-made spaces on the surface of the earth...every landscape is the place where we establish our own human organization of space and time." -J.B. Jackson, *Discovering the Vernacular Landscape*, 1984



Figure 2

[Microsoft Data Center]. 2008. San Antonio, Texas. JPEG file.
<http://opentechcontrols.com/>

INTRODUCTION

In her article “Behold the server farm,” which appeared in Fortune magazine in 2006, Stephanie Mehta describes the data center and its many extreme conditions; its massive size, prison-like security measures, large capital investment, and astounding energy usage. Extending beyond most articles written about the contemporary data center, which focus on issues of energy, technology, and economics, Mehta describes their physical presence, saying, “Most people don’t think of it this way, but the Information Age is being built on an infrastructure as imposing as the factories and mills of yore...They’re a weird mash-up of high tech (state-of-the-art three-quarter-inch blade servers) and heavy industry (row after row of diesel generators) wrapped in the architectural charm of a maximum-security prison.”¹

This thesis attempts to render architectural agency and aesthetics a part of the typological discussion of the data center and its placement in the rural American landscape. Architecture currently does not have agency in the design of data centers. In fact, the word architecture can easily be confused in reference to the data center, referring to the “architecture” of the network or the software on the servers, rather than the building itself.

¹ Mehta, Stephanie, “Behold the Server Farm,” Fortune, July 28, 2006.

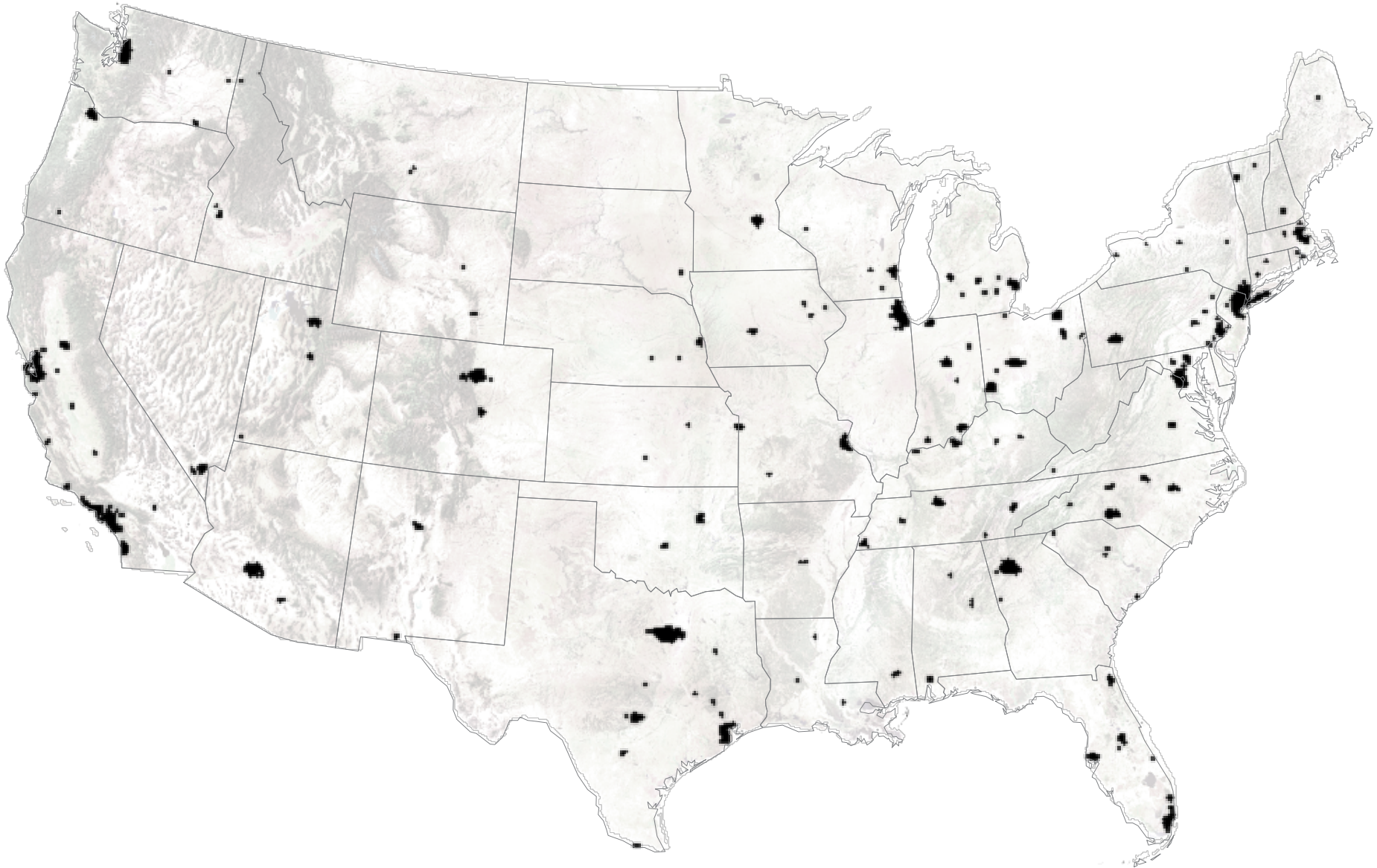


Figure 3

[U.S. Data Center Locations].
Interactive map.
datacenterknowledge.com

PROGRAM

The data center could be understood as extending, but transforming the disciplinary lineage that looks to buildings such as factories in early modernity as a means of altering disciplinary design practices to articulate the dramatic reorganization of space and time. This is best demonstrated in the AEG Turbine Factory of 1910 designed by Peter Behrens. The AEG turbine factory demonstrates Behrens' classicist expression, and his belief that fundamental artistic formal principles could heighten the cultural importance of modern technology. Behrens uses symbolic expression, comparing the AEG turbine factory to the Greek temple, as a means of expressing the transformative impact of modern German industry.² He set an artistic standard for modern factories, and rendered architectural agency a part of the transformative period of modernization. Influences of the AEG turbine factory on the design of other modern factories and corporate headquarters can be seen in examples such as the Fagus Factory (1913) by Walter Gropius, the John Deere Headquarters (1964) by Eero Saarinen, and the Johnson Wax Headquarters (1939) by Frank Lloyd Wright.

2 Colquhoun, Alan. *Modern Architecture*. Oxford: Oxford UP, 2002. 64-67.



Figure 4

[AEG Turbine Factory designed by Peter Behrens]. 1910.
Berlin, Germany. JPEG file.
<http://www.flickr.com/photos/josepha/4484044561/>

Figure 5 Image credits

[AEG Turbine Factory designed by Peter Behrens]. 1910. Berlin, Germany. JPEG file. <http://www.flickr.com/photos/josepha/4484044561/>

[John Deere Headquarters designed by Eero Saarinen]. 1964. Moline, Illinois. JPEG file. <http://rebeccareilering.wordpress.com/tag/history/>

[UCLA Chiller Plant designed by Jones Partners]. 1994. Los Angeles, California. JPEG file. <http://archinect.com/firms/project/6790084/ucla-chiller-plant-co-generation-facility/41304005>

[Microsoft Data Center]. 2008. San Antonio, Texas. JPEG file. <http://opentechcontrols.com/>



The data center has similar cultural significance to the modern factory, housing the most coveted thing in contemporary society, information. It is the nerve system of business and society, in addition to the storehouse of our collective cultural memory.³ Despite the fact that all aspects of our daily life are dematerialized into this invisible cloud network, these massive buildings are a physical reminder of our attachment to material means. They are some of the largest buildings of our generation in addition to the physical representation of the reorganization of space and time by digital technologies. As Karl Marx observed, “While capital ...must strive to tear down every barrier...to exchange and conquer the whole earth for its markets, it strives on the other side to annihilate this space with time.”⁴

3 Vanderbilt, Tom. “Data Center Overload.” The New York Times [New York City] 08 June 2009. Print.

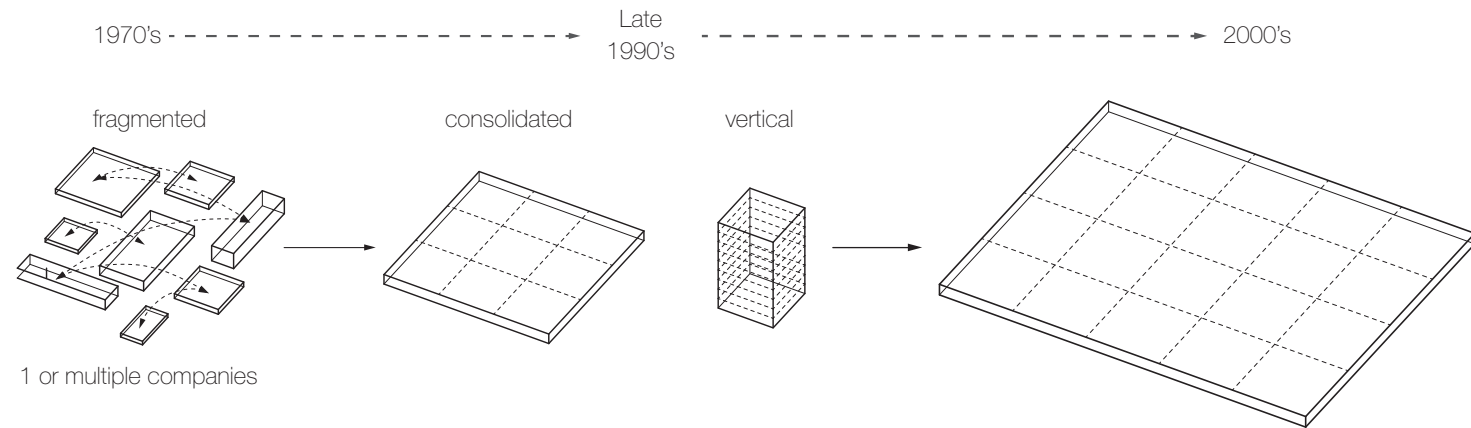
4 Marx, Karl. The Grundrisse. New York: Harper & Row, 1971. 538-39. Print.

Figure 6

[Facebook data center interior].
Prineville, Oregon. JPEG file.
<http://earthandindustry.com/2011/04/facebook-to-share-data-center-and-server-designs/prineville-1/>



Figure 7
Data Center transformation diagram



The contemporary data center emerged in the late 1990's during the dot com bubble, but its history began during the early computing industry of the 1970's. As computer use became more widely distributed, information technology systems became more complex, and companies organized IT infrastructure in specifically designed rooms or in former computer rooms. Groups of servers were a solution to organizing increasingly complex information systems, and the term "data center" was born. The data center has since experienced a series of transformations; the most fundamental shift is from smaller, decentralized data centers, to larger, consolidated facilities. As the need for IT infrastructure grows, the cost of operating smaller decentralized data centers becomes too expensive. The government, large companies, and collocation facilities are centralizing their data center infrastructure to save on operation and space costs in addition to controlled oversight of information. Intel consolidated 136 of its data centers into 8 larger facilities located strategically across the world, and Hewlett Packard initiated a plan in 2006 to consolidate 85 data centers into 6.⁵ These buildings range from 100,000 ft² to upwards of 1,000,000 ft², and they continue to get larger with increased storage needs and cloud computing.

5 Rath, John. "Data Center Site Selection." Data Center Links. Rath Consulting, 2007. Web. Aug. 2011. <datacenterlinks.com>.

Figure 8

[Facebook Data Center].
 Prineville, Oregon. JPEG file.
<http://www.datacenterknowledge.com/archives/2010/01/21/its-official-facebook-is-oregons-company-x/>

[Google Data Center].
 Seattle, Washington. JPEG file.
<http://gawker.com/191080/googles-data-center-done-gone-and-scared-me>

[Apple Data Center].
 Maiden, North Carolina. JPEG file.
 excerpted by a new video by Bill Wagenseller.
<http://www.datacenterknowledge.com/archives/2010/10/24/video-the-fully-operational-idatacenter/>

[Somerset Technology Park]
 New Jersey. JPEG file.
<http://www.datacenterknowledge.com/archives/2011/02/16/russo-plans-large-nj-data-center-development/>

facebook data center | prineville, oregon



google data center | seattle, washington



apple data center | maiden, north carolina



somerset technology park | new jersey



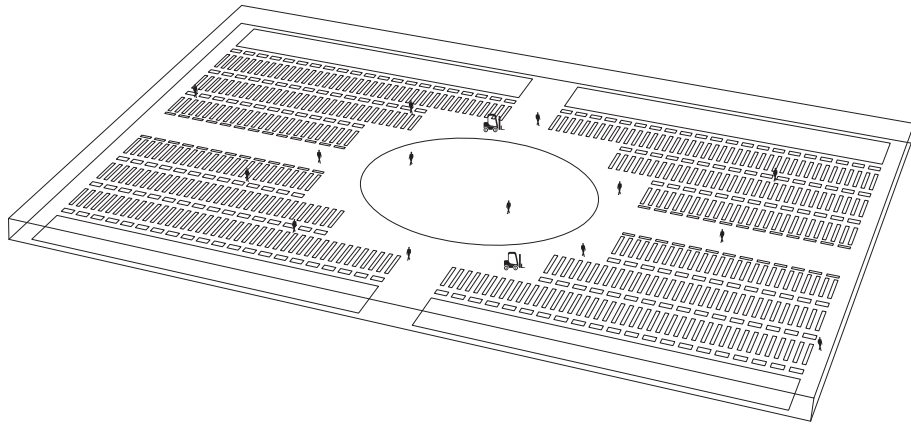


Figure 9
Visual perspectives of the data center typology

ENVELOPE

In "The Politics of the Envelope: A Political Critique of Materialism," Alejandro Zaera Polo describes four types of building envelopes, one of them is the Flat- Horizontal Envelope. He states that the "Flat-horizontal envelopes perform by delimiting edges, frontiers and boundaries and sheltering the domains they enclose, operating primarily on the articulation between natural and artificial."⁶ This envelope type describes the data center, a massive, flat horizontal building with clear boundaries meant to securely enclose its contents, computer servers. Likewise, because of their size and form, the only comprehensive understanding of this type of building is from an aerial viewpoint, and the experience of them is otherwise fragmented. This is partially a result of their size, but also related to their desire to remain invisible.

6 Zaera Polo, Alejandro. "The Politics of the Envelope: A Political Critique of Materialism." Volume 17 (2008): 82. Print.

Figure 10

area | 500,000 ft²
volume | 10,000,000 ft³

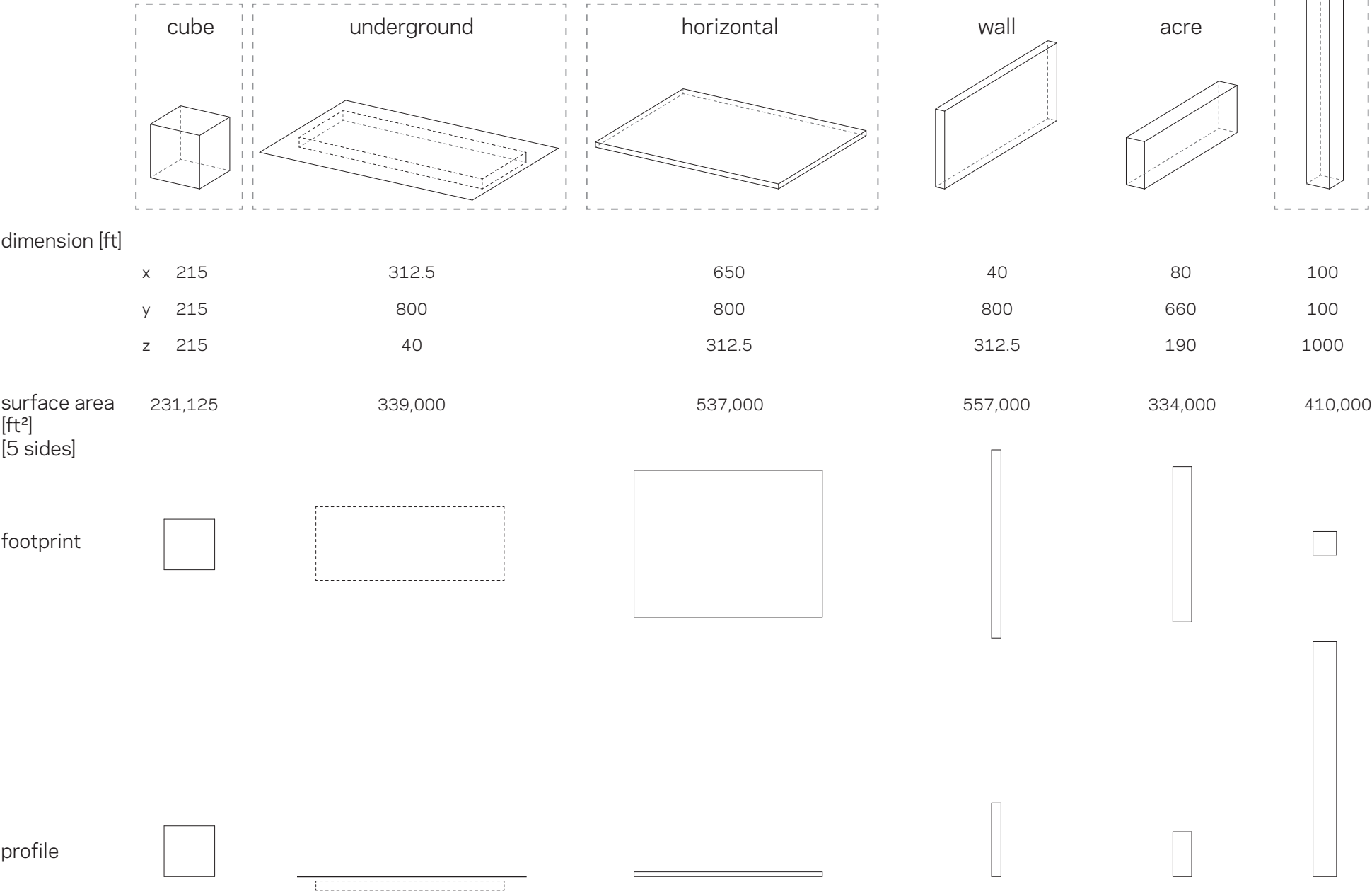




Figure 11

[Microsoft Data Center]. 2008.
San Antonio, Texas. JPEG file.
<http://opentechcontrols.com/>

This alters architecture's traditional role of representation as data centers are more concerned with logistics; flows of traffic, ventilation, and security, than with monumentality and identity.

This thesis speculates an identity for the data center by reimagining its internal and external relationships through explorations of form, orientation, envelope, and presence in the landscape. These issues can be engaged by focusing on the point at which the architectural and programmatic problems of the data center converge, the building form and envelope.

This thesis engages the building envelope not simply as a single surface, but as an expanded surface that considers not only logistical and environmental issues, but also engages the social and political architectural questions related to the identity of the data center in the rural landscape.

ENVELOPE : Energy

The building envelope is the physical manifestation that distinguishes between outside and inside, public and private, natural and artificial.⁷ In the data center the envelope is a performative interface, air is continually pumped in and out through ductwork, and a single secure perimeter is created by a blind box exterior that ignores any representational potential. By exploiting the data center's envelope as the convergence of architectural identity and logistical interface, I have attempted to begin to dissolve the data center's massive blind box enclosure. In a typical data center about 40% of the square footage is HVAC equipment used to cool server infrastructure, using as much energy as 25,000 homes.⁸ Server infrastructure is organized through a series of hot and cold aisles.

7 Zaera Polo, Alejandro. "The Politics of the Envelope: A Political Critique of Materialism." Volume 17 (2008). Print. - or on surface?
8 "Powering the Cloud." The ABB Group. Web. 23 Sept. 2012. <<http://www.abb.com>>.

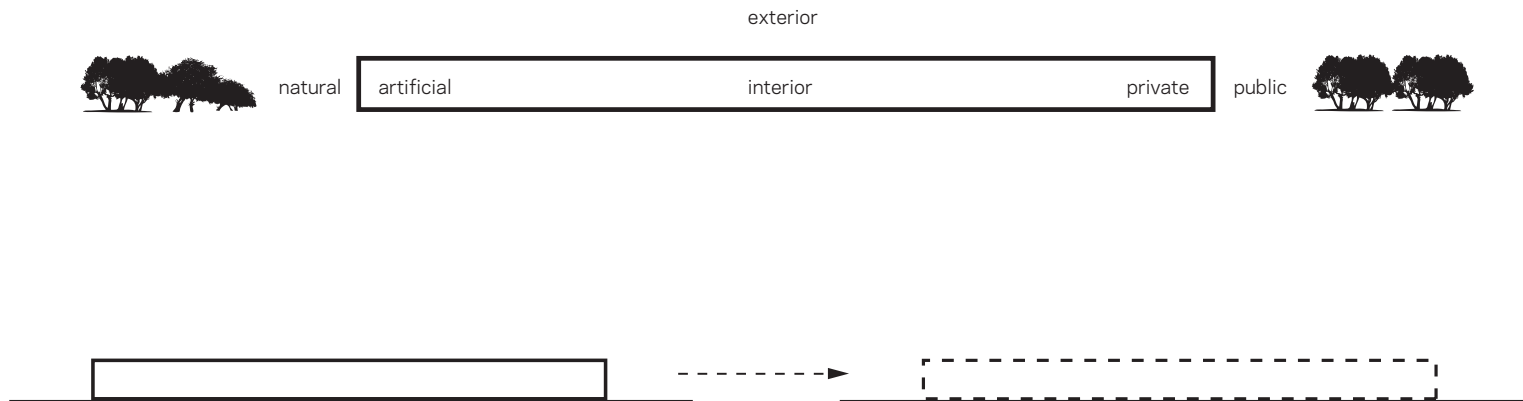


Figure 12

Figure 13
Typical data center program distribution

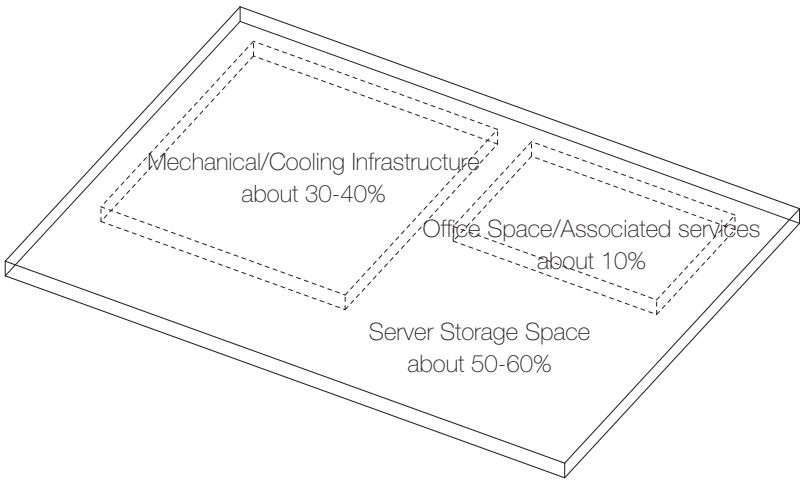
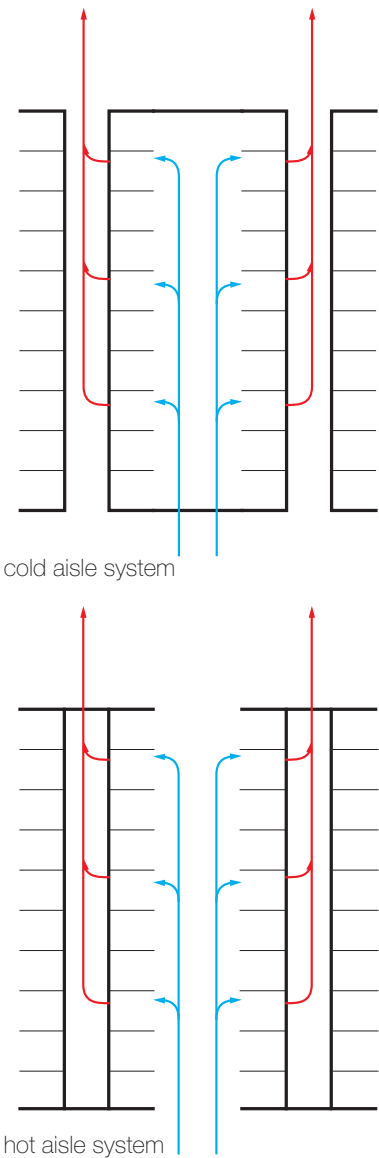


Figure 14



Depending on the location and type of cooling system in place, companies will choose to either have a hot or cold aisle system in which cold air used for cooling and hot air produced from the servers is kept separate for air handling efficiency. Server racks get extremely hot, and for every dollar spent to power a server, another dollar is spent to keep it cool.⁹ Air handling units specifically designed for data centers are called CRAC units, which stands for computer room air conditioners. Outside air economizers are also used with CRAC units to alleviate energy costs and depletion of resources by using outside air for cooling in colder climates.[see page 13] Data centers are extremely dense, full of large static equipment, but simultaneously empty, full of air used for cooling. By orienting the envelope vertically and re-strategizing the movement of air, aesthetic design opportunity is gained in the representation of the vertical façade and spatial qualities where the envelope begins to wrap the interior. [see page 14-17 for related

⁹ Mehta, Stephanie N. "Behold the Server Farm." Fortune 28 July 2006. Print.

Figure 15
Optimum Chimney Effect Ratio

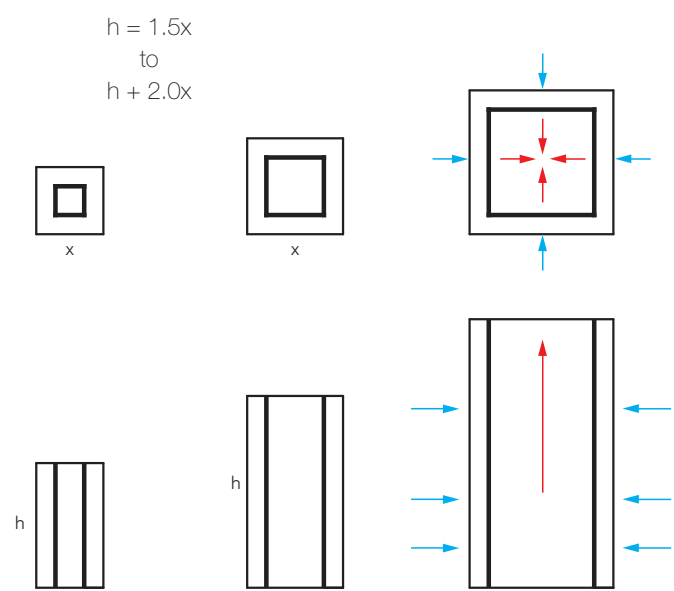


Figure 16
Diagrammatic interior circulation and air movement strategies

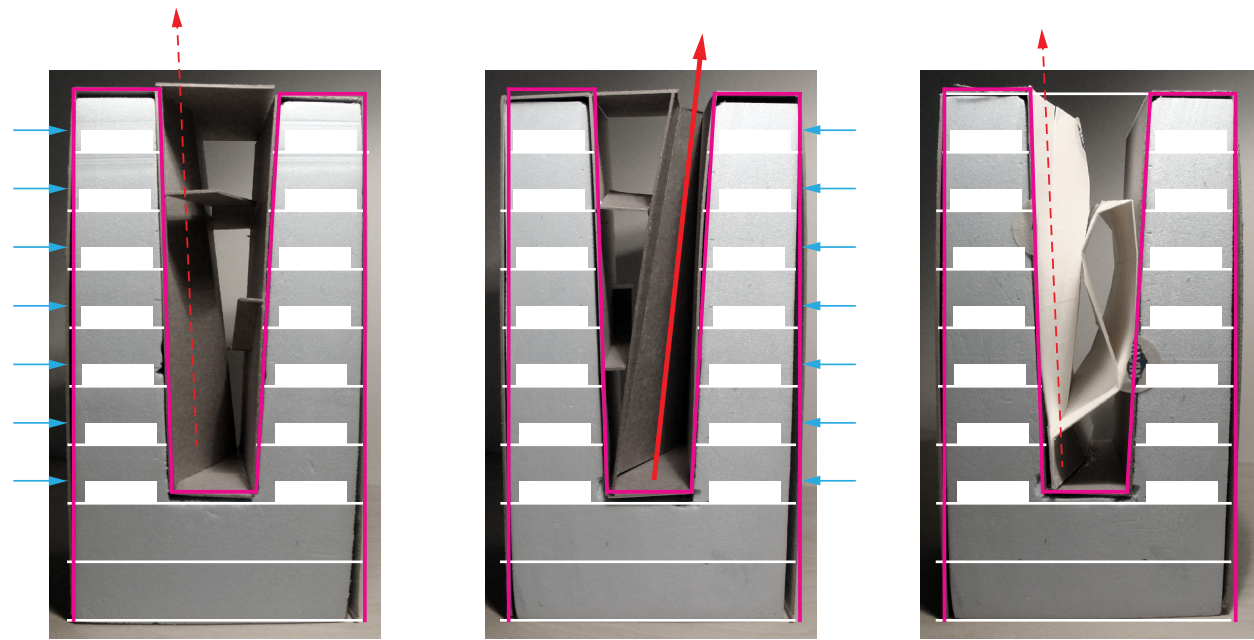
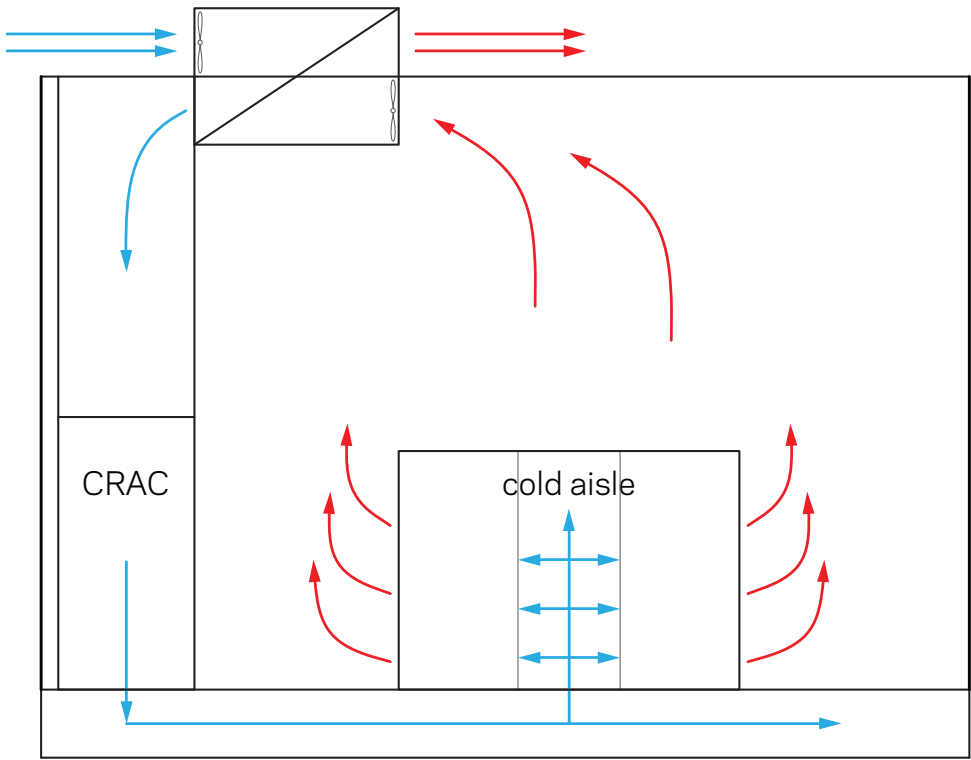


Figure 17

Indirect Exchange

CRAC return air is passed through a heat exchanger cooled by outside air



Direct Exchange

CRAC return air is expelled and replaced with filtered outside air

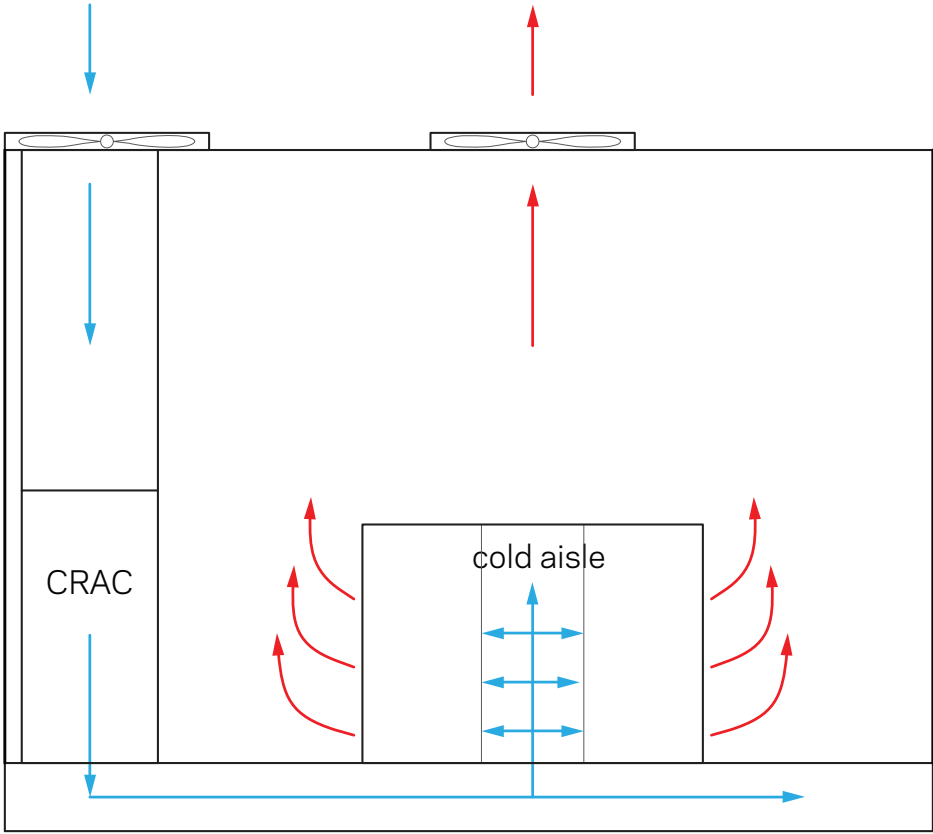


Figure 18
Plan and Diagrammatic Section Cuts

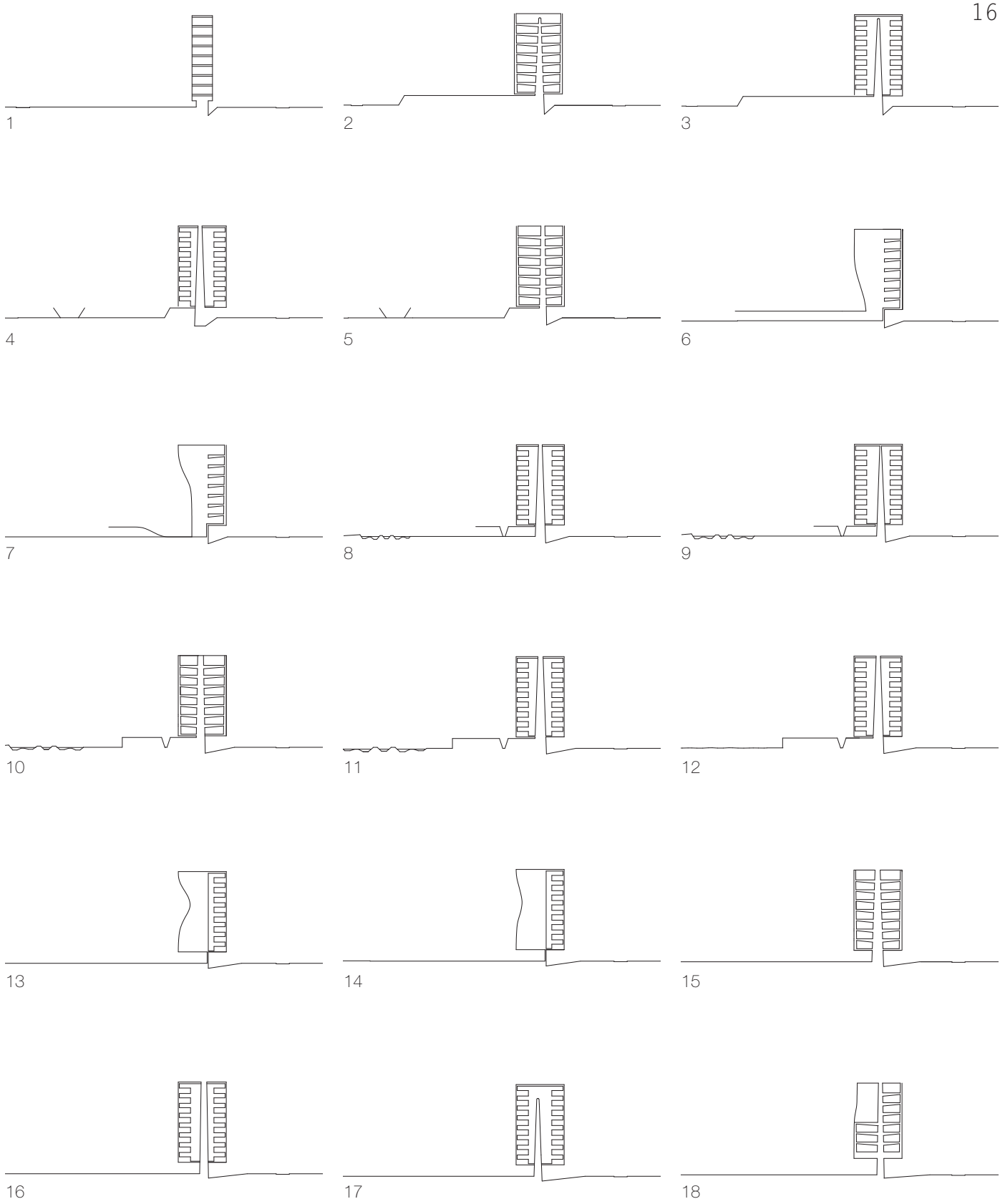
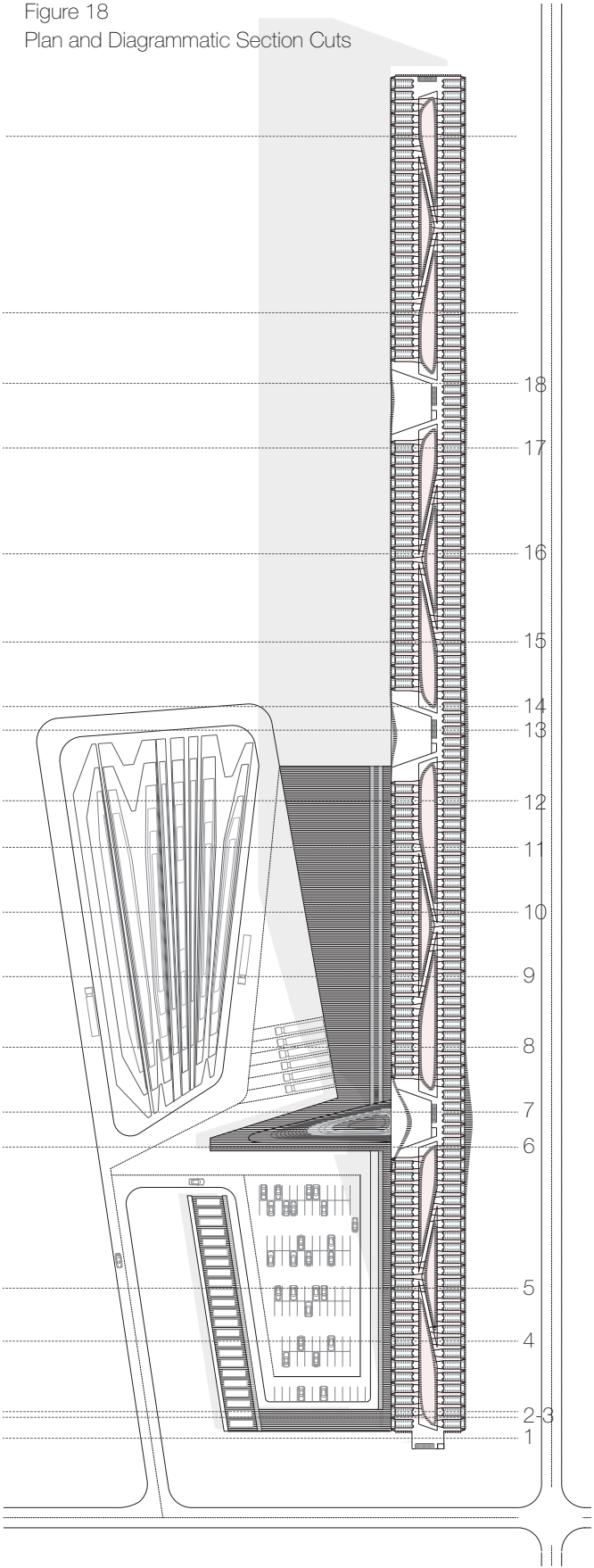


Figure 20
Sections

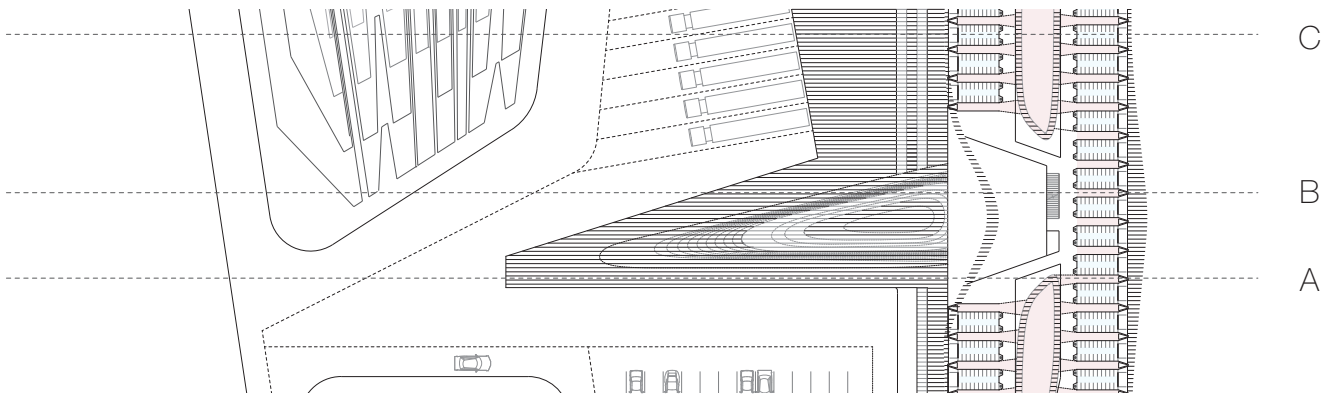
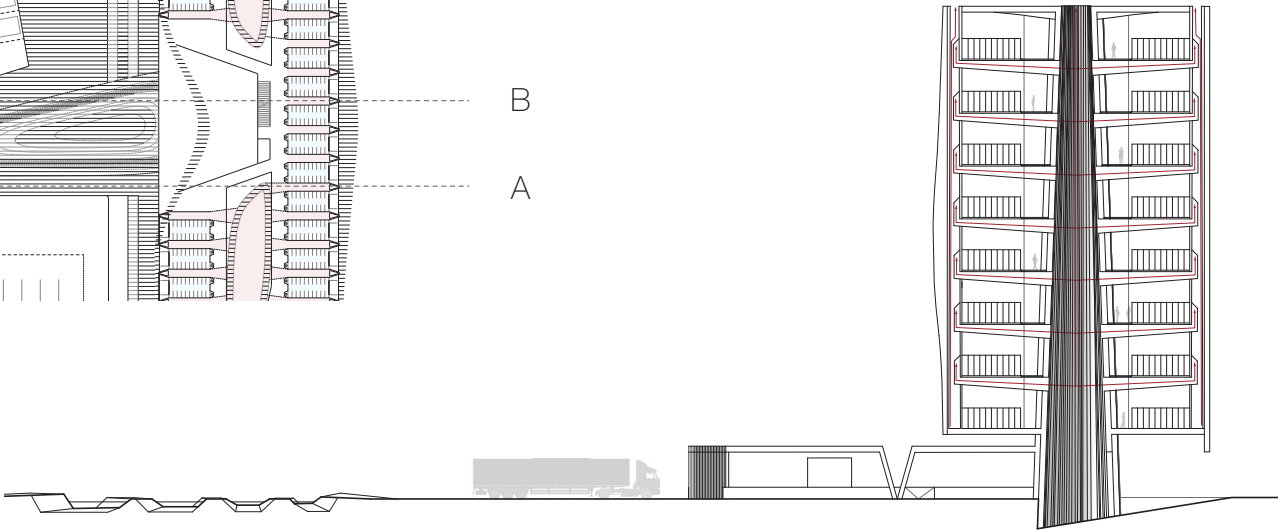
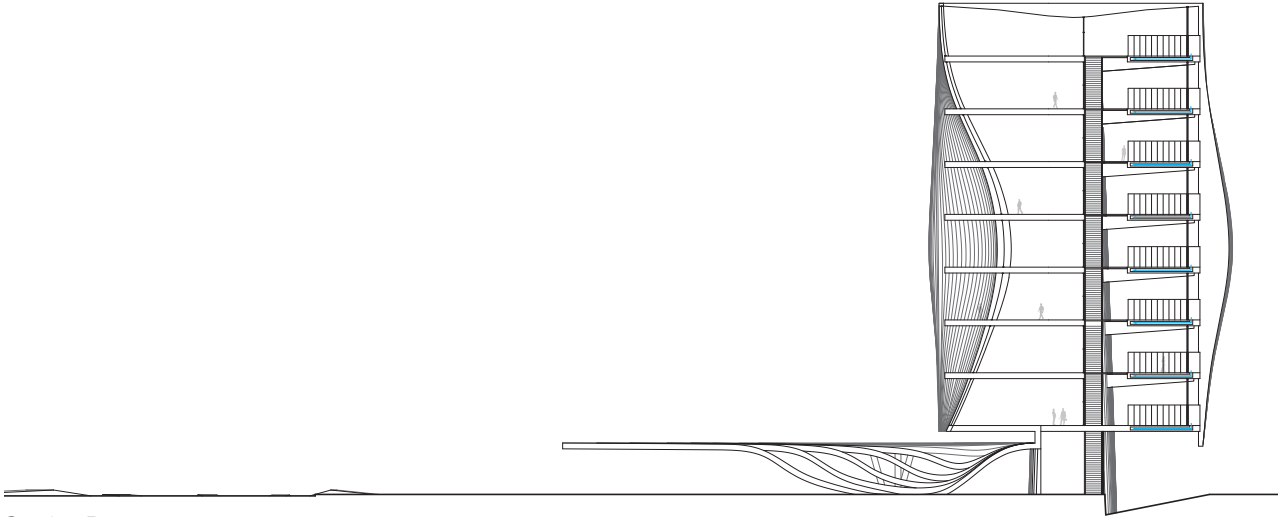


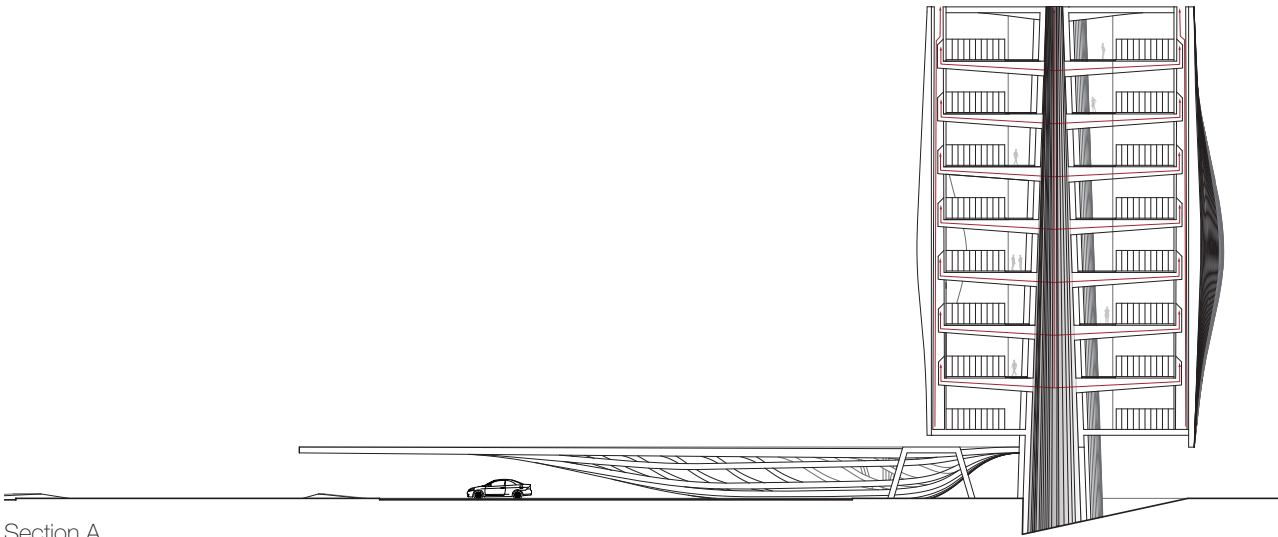
Figure 19
Detailed Plan



Section C

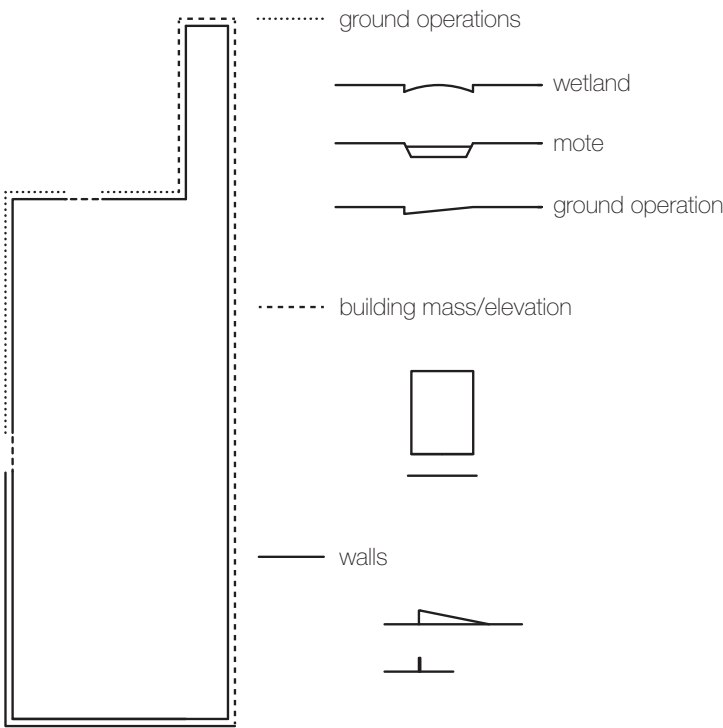


Section B



Section A

Figure 21
diagrammatic security zones



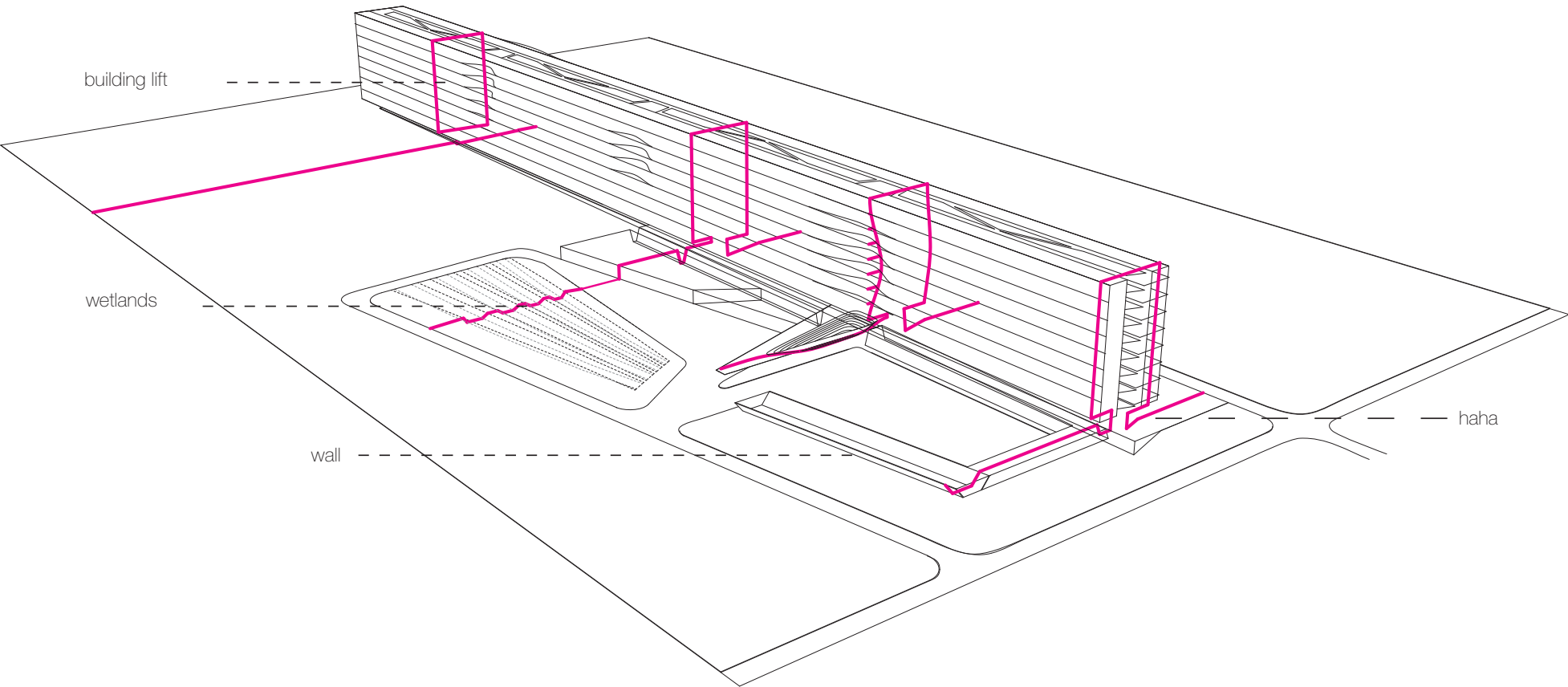
ENVELOPE : Security

drawings]

In addition to energy concerns, another important consideration for Data Centers is security. Rich Miller, the creator of the website Data Center Knowledge, the industry's leading data center information website, says "It's like 'Fight Club,' the first rule of data centers is: Don't talk about data centers."¹⁰ Not only are data centers the storehouse of YouTube videos, but they also secure some of the most private and important business and government information. The National Security Agency is building a \$1.5 billion data center in Utah, and has been in recent media controversy after an article written by Jane Mayer appeared in the New Yorker that specifies the NSA's plans of electronic monitoring of American citizens.¹¹ Whatever their purpose, Data centers need to be highly secure, and they are typically secured by their singular envelope, fences, and placement in remote locations. Through the wrapping and manipulation of the building profile, more subtle ways of securing the data center can be achieved that also

10 Vanderbilt, Tom. "Data Center Overload." The New York Times [New York City] 08 June 2009. Print.
11 Miller, Rich. "The Apple-Google Data Center Corridor." Data Center Knowledge. 4 Aug. 2009. Web. 29 Aug. 2011. <<http://www.datacenterknowledge.com/archives/2009/08/04/the-apple-google-data-center-corridor/>>.

Figure 22
site/building operation strategies



SITE and STRATEGY

relate to the rural landscape where they are built.

As the size of data centers increases, they are more often sited in rural areas, taking advantage of tax incentives, lower land prices, proximity to energy resources, and security. John Rath outlines the most important factors when siting data centers in his consulting guide as susceptibility to disasters (natural and man-made) and weather in addition to workforce and business climate, which includes proximity to power and land.¹² Quincy, Washington, a town with a population of about 5,000 people is now the host of five high profile data centers for companies that include Yahoo, Intuit, Sabey, and Microsoft's 1.4 million square foot campus. Google also purchased 30 acres outside of Quincy for a data center that will contain an estimated half-million to million servers.¹³ Quincy is conveniently located within close proximity to the Columbia River, which is an ample resource of cheap renewable energy, in addition, the area has inexpensive land value and state tax incentives for rural data centers.¹⁴ These massive, rectangular data centers literally take the place of former bean fields, as a series of large sprawling blind box buildings occupying the landscape, having a huge impact on the land, resources, and community that they occupy. Re-strategizing the envelope provides opportunistic potential for the data center

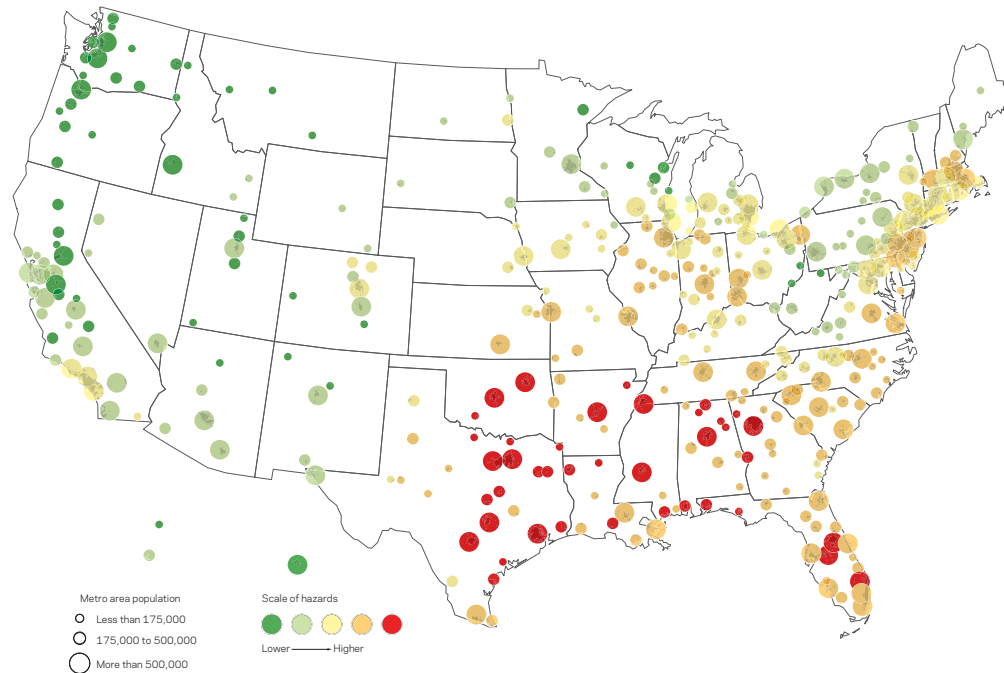


Figure 23
[U.S. Natural Disasters Map]. 2011.

- 12 Rath, John. "Data Center Site Selection." Data Center Links. Rath Consulting, 2007. Web. Aug. 2011. <datacenterlinks.com>.
- 13 Mehta, Stephanie N. "Behold the Server Farm." Fortune 28 July 2006. Print.
- 14 Sverdlik, Yevgeniy. "Data Center Dynamics." Data Center Dynamics. Data Center Dynamics, 18 Aug. 2011. Web. 20 Sept. 2011. <<http://www.datacenterdynamics.com/focus/archive/2011/08/washington-state>>.



Figure 24

[Data centers in Quincy, Washington]. 2010.

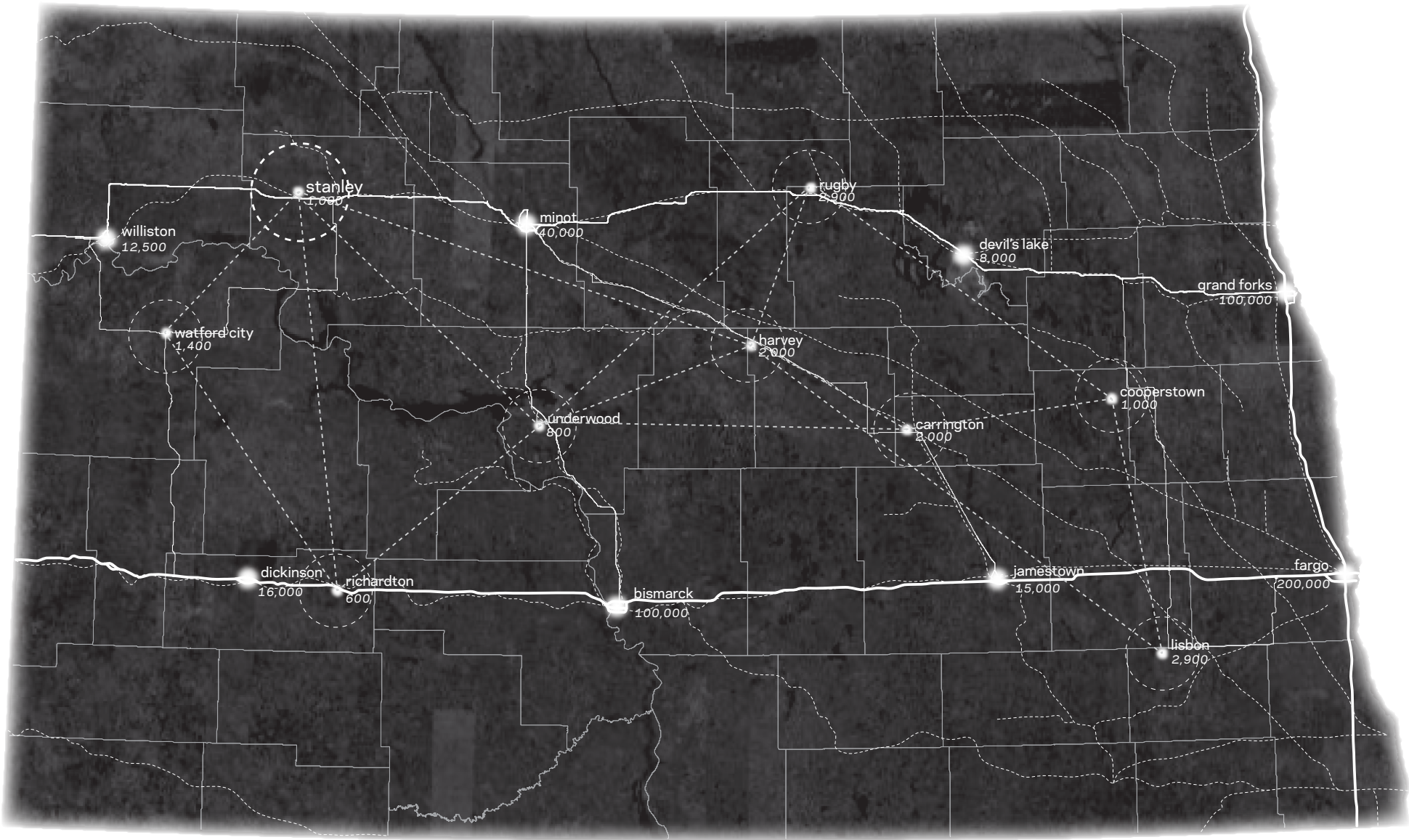
Quincy, Washington. JPEG file.

<http://www.datacenterknowledge.com/archives/2010/02/01/group-pushes-for-change-in-washington-state/>

and its relationship to land, environmental context, and visual effect.

I am proposing a poly-centered data farm network in rural North Dakota, focusing specifically on Stanley, ND as a node and designing one of its data centers. Although I have designed one data center, it could be a system that defines a general framework that is modified by other companies building data centers within the region. This way,

Figure 25



county	mountrail	mckenzie	grant	mcclean	wells	foster	ransom
population, % change, 2000-2010	-5.5% (15.7%)	-9.8% (10.9%)	-15.7%	-3.7%	-17.5%	-11.1%	-7.4%
persons 65 years old and over, percent, 2009	16%	14.5%	25.9%	21.3%	28.3%	28.3%	19.5%



Figure 26-29
original images taken during North Dakota research trip



23

the data center can become part of a regional framework, in addition to defining an identity for the data center.

The rural Jeffersonian landscape of the upper Midwest serves as the site of investigation. The rural Midwestern landscape is characterized by expansive horizontality and the uniformity of the Jeffersonian grid that is punctured by vertical elements such as windmills and grain silos that create a series of profiles on the horizon. The singularity of the form of this landscape is a blank canvas for the changes that the



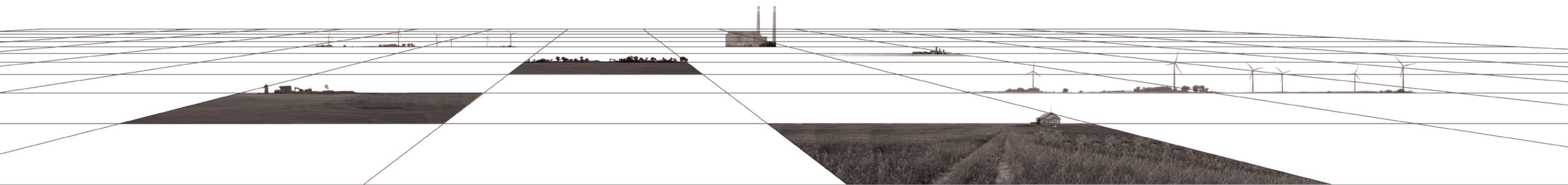


Figure 30
Jeffersonian grid diagram

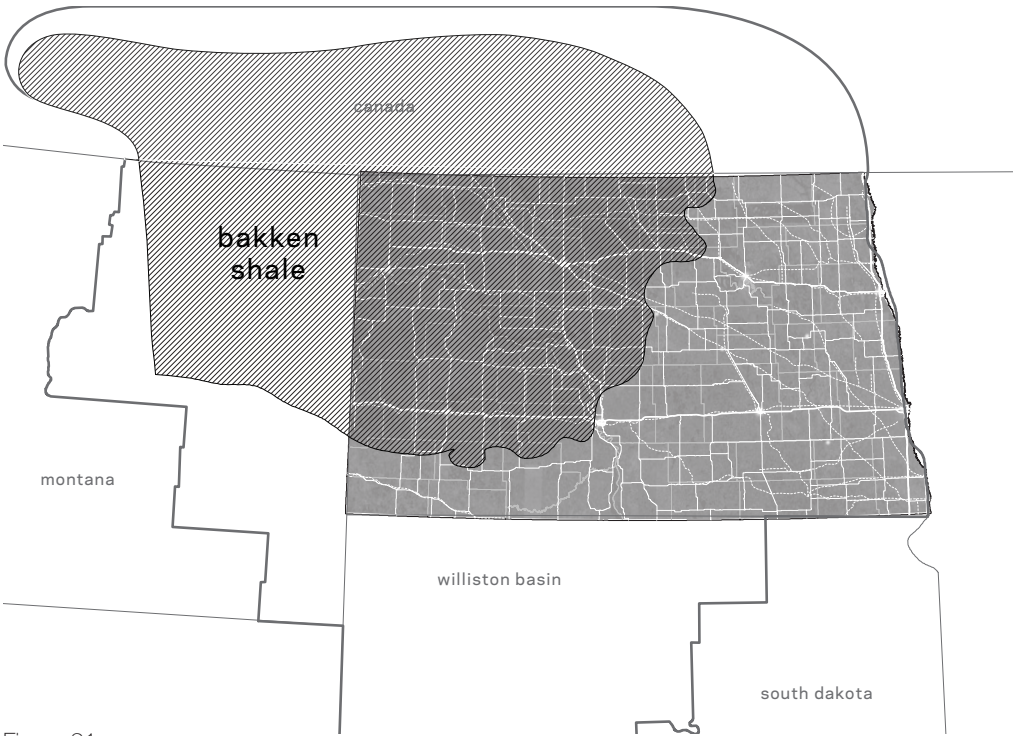


Figure 31
Regional context

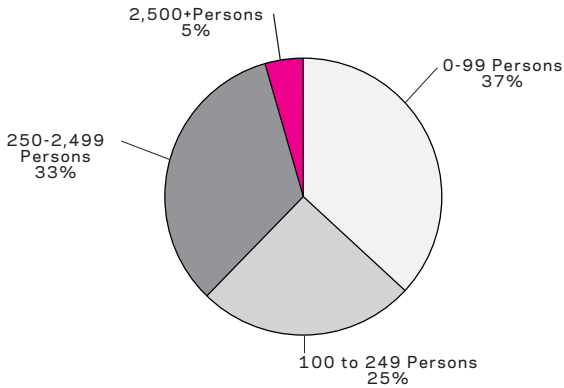
surrounding environment so clearly imposes.

The land of the upper Midwest once promised agricultural prosperity, but the overly eager development of the western frontier structured its own obsolescence. As globalization takes hold, world populations urbanize, resulting in the widespread “hollowing out” of rural regions. North Dakota is an extreme case of this phenomenon. There are approximately 650,000 people living in North Dakota, and 75 percent of them now live in 8 metropolitan towns. Today, America’s rural population accounts for 16% of the total population, whereas in 1910 rural populations reached 72%.¹⁵ Data centers could be an economic resource for rural communities. While

15 Konigsberg, Eric. “Kuwait on the Prairie.” The New Yorker 25 Apr. 2011. Print.

Figure 32

North Dakota City Size Distribution: 2009



Over **70%** of North Dakota's Population lives in **8** cities

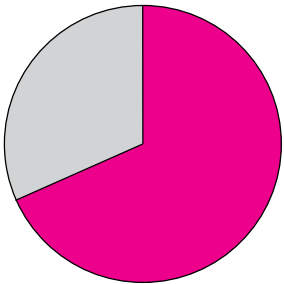
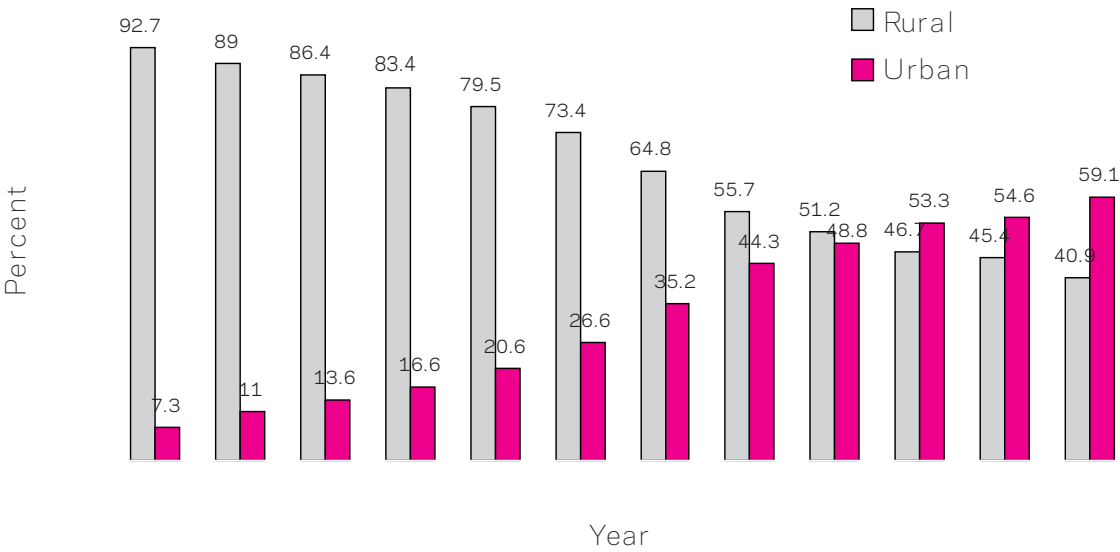


Figure 33

North Dakota Rural-Urban Population Distribution, 1900-2020

Source: U.S. Bureau of the Census, Decennial Censuses.



Prepared by the North Dakota State Data Center
January 2011

Figure 34

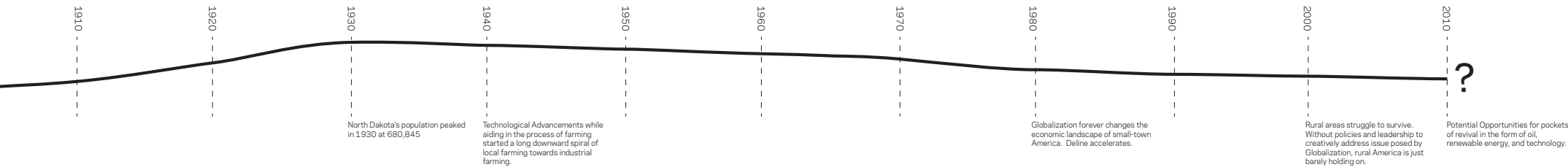
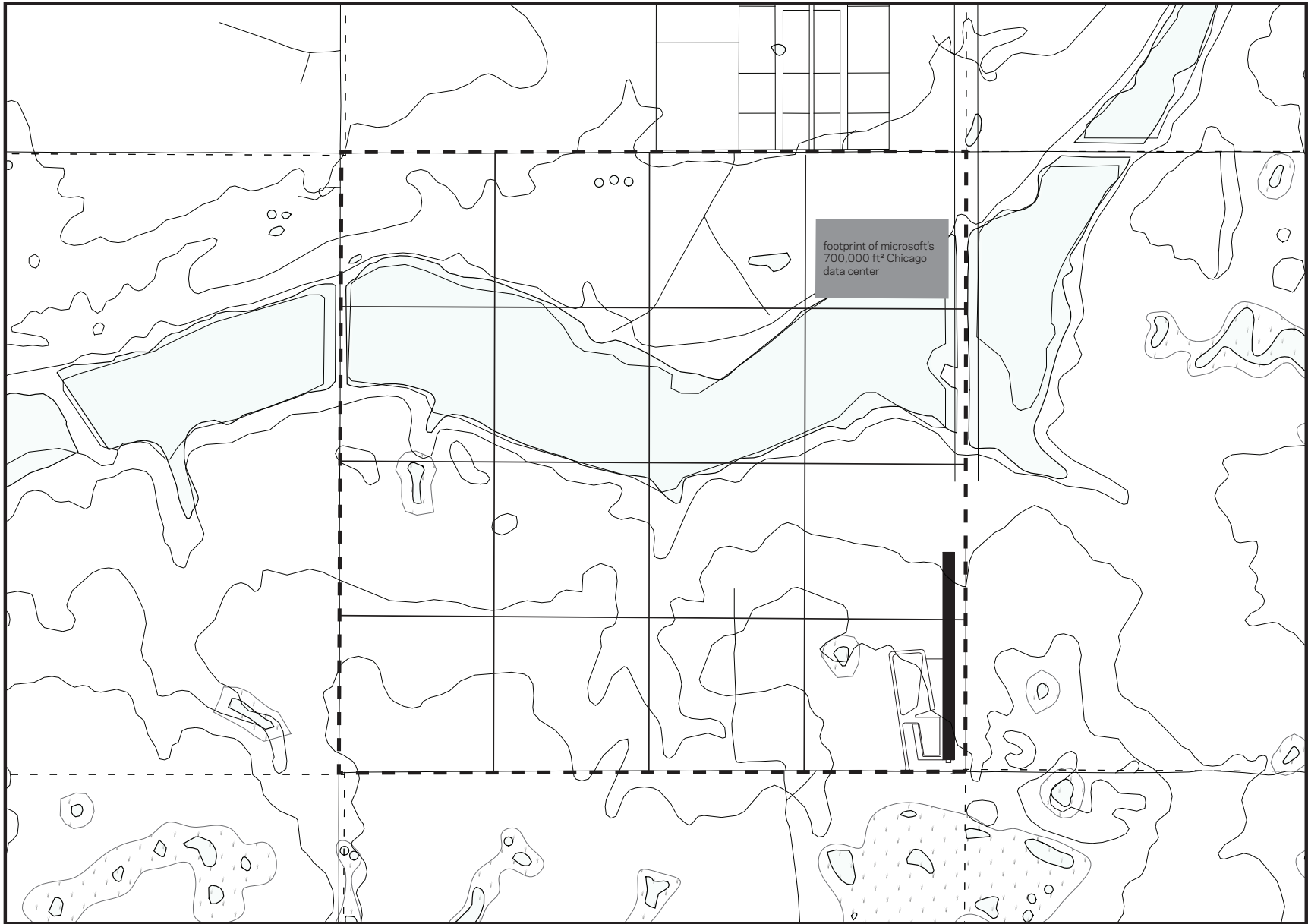
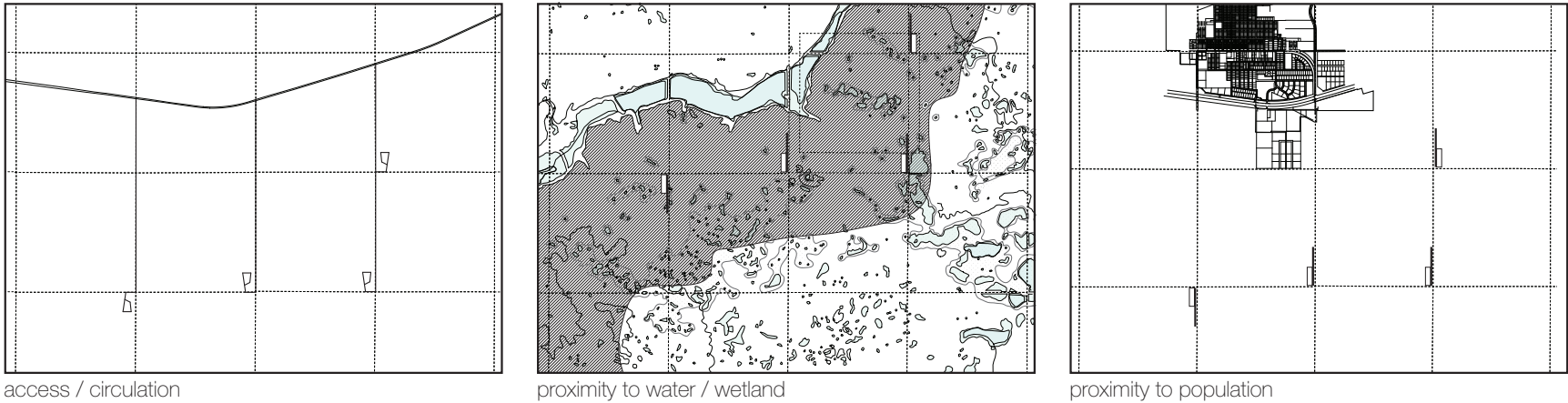
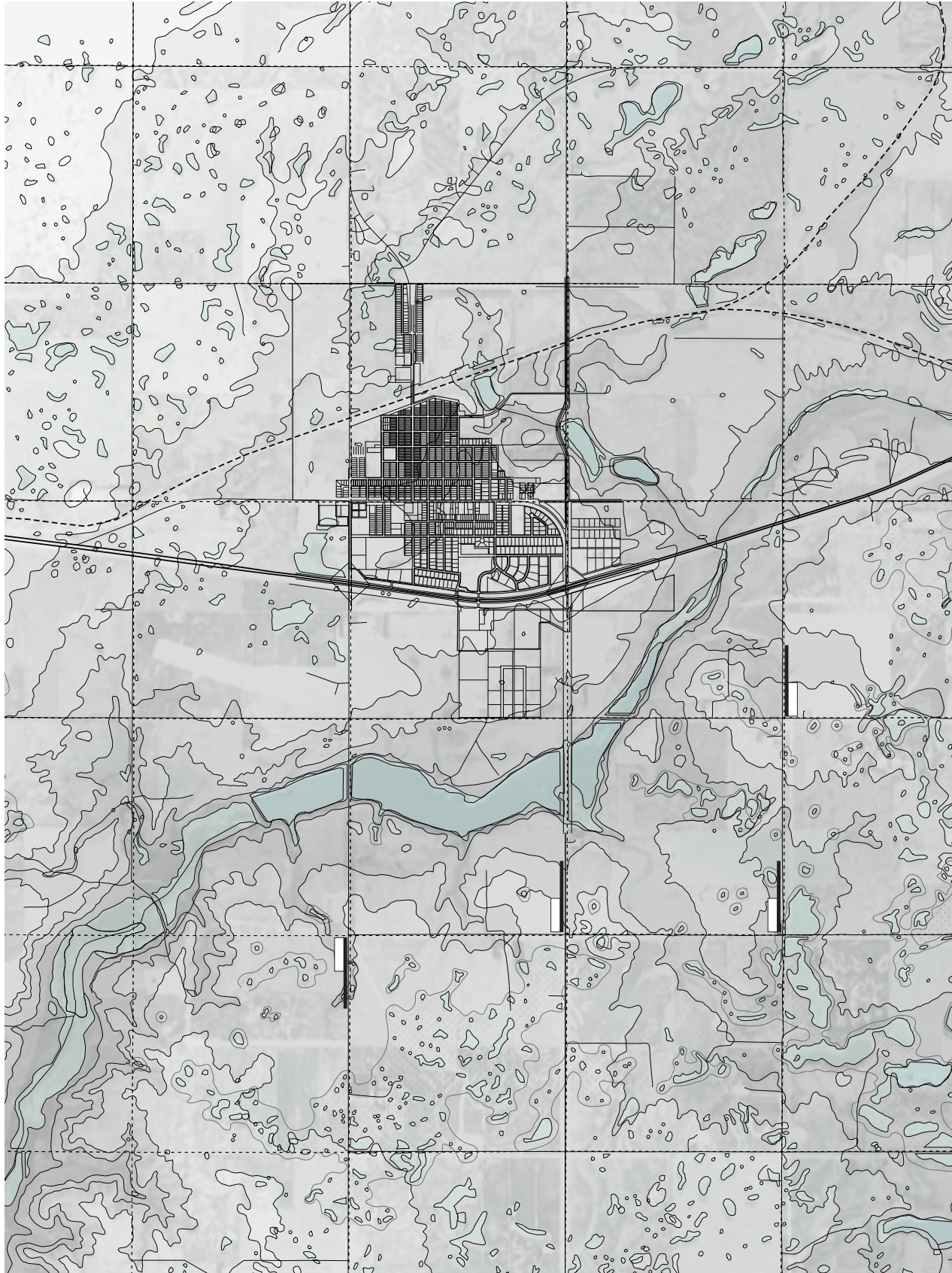


Figure 35



Zoomed Site Plan

Figure 36
Stanley proliferation strategy



each data center only provides about 50-200 jobs, for many rural hollowing out communities, this is a significant amount.

The center of culture, in large cities and small towns, which was once centered along a main street, has been redefined by globalization, altering previous notions of space and time. New forms of interaction have emerged, ones whose geography are difficult to map, seemingly invisible, existing in remote data centers around the world. Rural communities could take advantage of the local and global relationships of the data center, and strategic development could begin

Figure 37

[Chinese Factory]. 2009. JPEG file.
<http://ensaiosimperfeitos.blogspot.com/2009/11/connecting-with-chinese-workers.html>

[Data center worker]. JPEG file.
http://www.123rf.com/photo_6896243_kyiv-ukraine--nov-16-worker-at-data-center-of-volia-company-during-open-doors-day-on-november-16-200.html



1000

50 - 200

difference in density

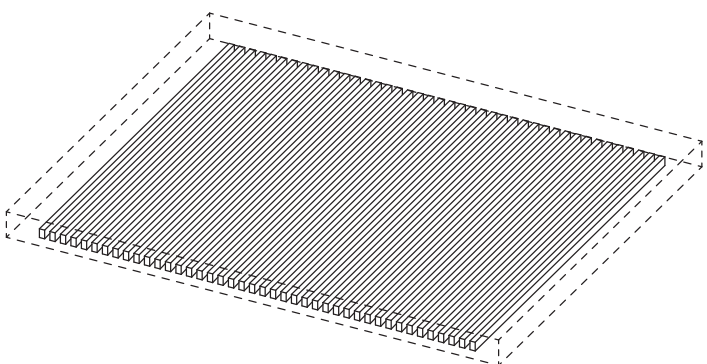
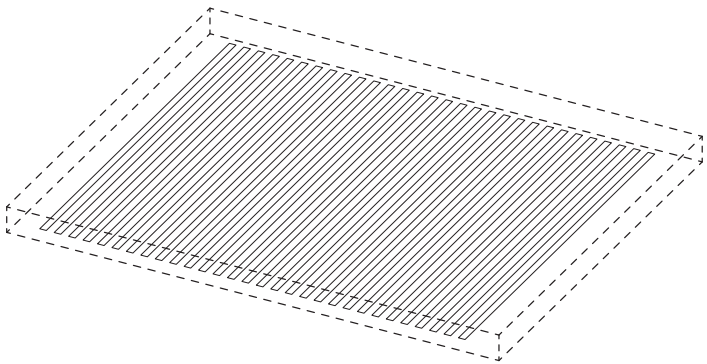


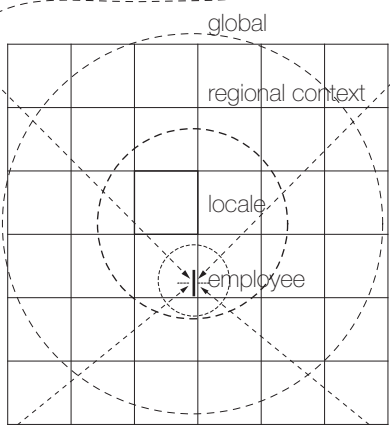
Figure 38

program logistics

energy

geographic/security

people/density



to define a new type of regional geography. The Data Center in this case has the potential to exploit its local and global relationships. Data centers operate at both a local and global scale. Server infrastructure is made in factories with thousands of workers and delivered from across the globe to U.S. data centers that are managed by less than 100 people. At the same time that they remain incomprehensible to their local context, from the viewpoint which they enable, the global information public, they are ubiquitous. The shift to rural data farms strikes an interesting metaphor to the agricultural farm. Just as early ties between agricultural fields to the city enabled denser urban development, server farms enable urban areas to be digitally



Figure 39
Exterior Rendering

connected. Ironically, rural areas, previously thought to be unconnected, become an integral part of a national and global infrastructure.

The mass of the data center here becomes a series of profile lines related to the landscape that together create specific spatial moments on the interior and abstract effect from the exterior. In this way, the density of the data center begins to dissolve, and can be experienced differently from each orientation and broader scalar relationship. The data center is no longer a dumb, flat, blind box enclosure, but a series of lines, a thickness without thickness, a volume without volume, articulating an architectural identity for the data center and establishing it as a regional marker comparable to the grain silos, wind mills, and oil derricks that dot the Midwestern landscape.

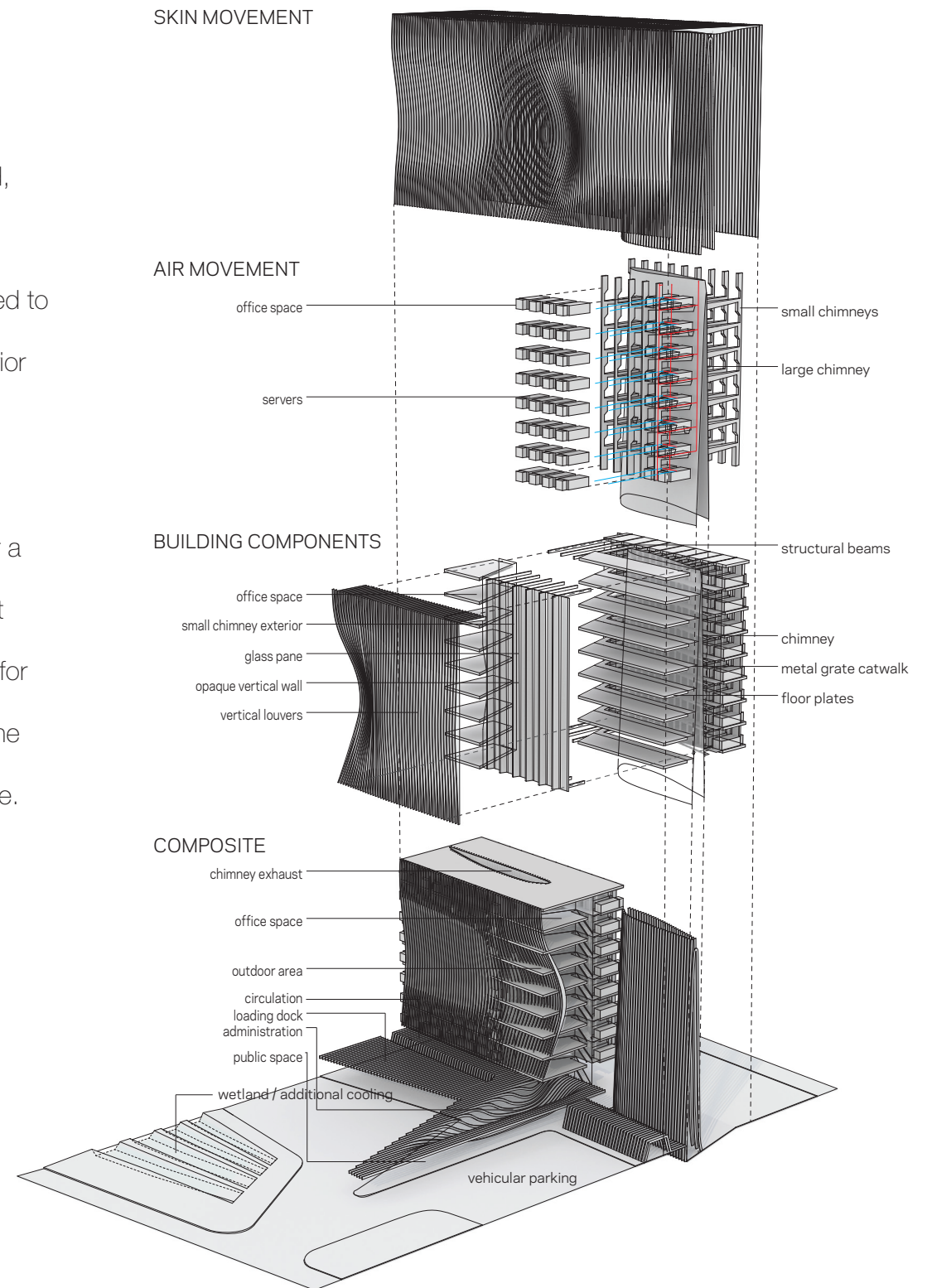
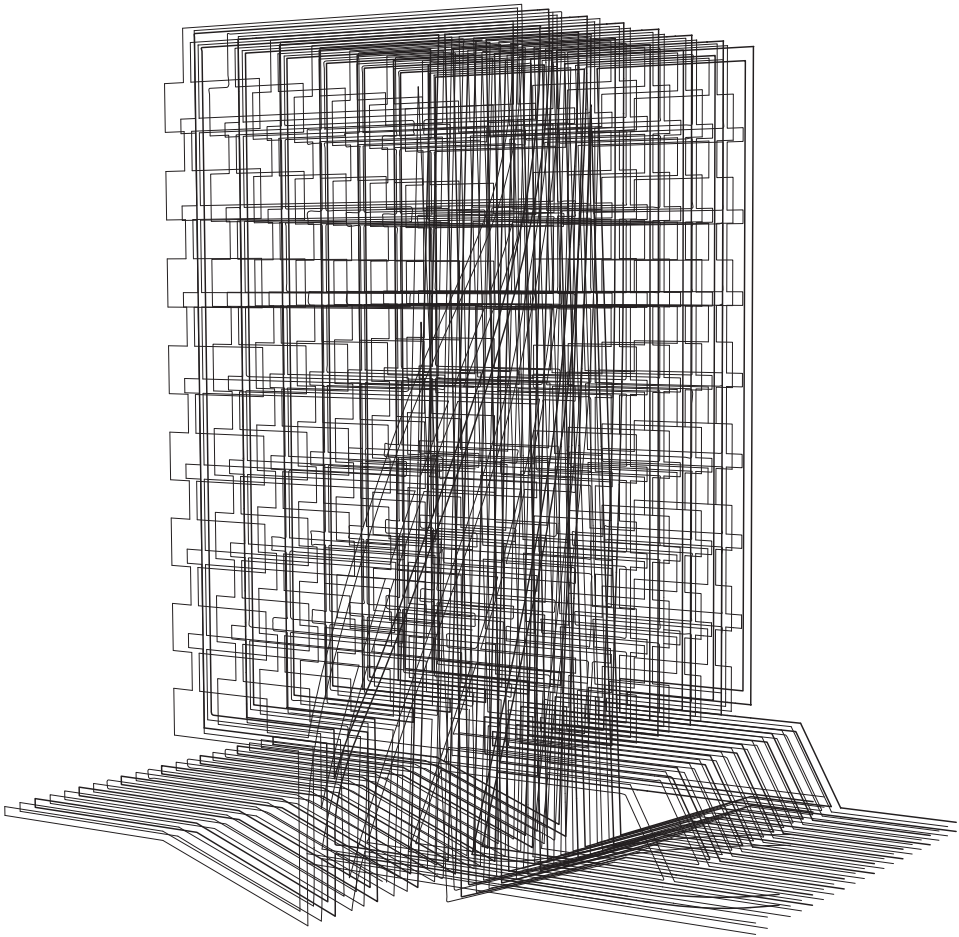
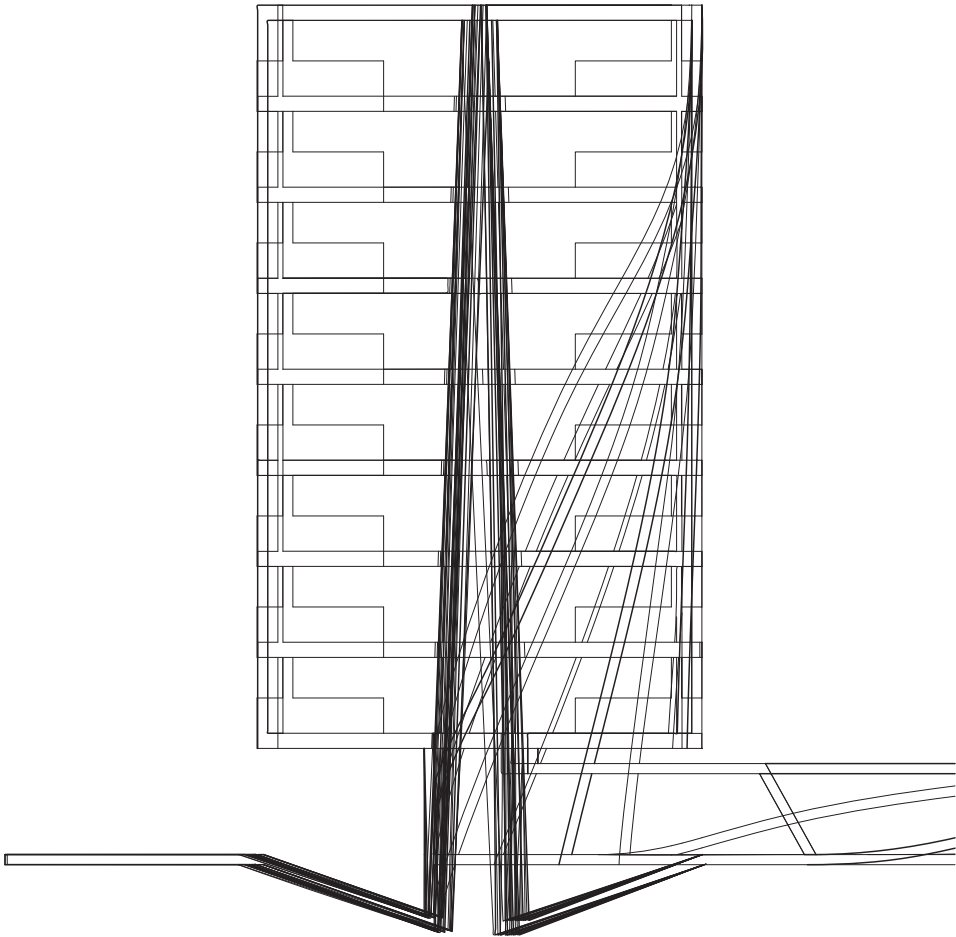


Figure 40
Exploded Axonometric

Figure 41
Interweaving Lines Diagrams



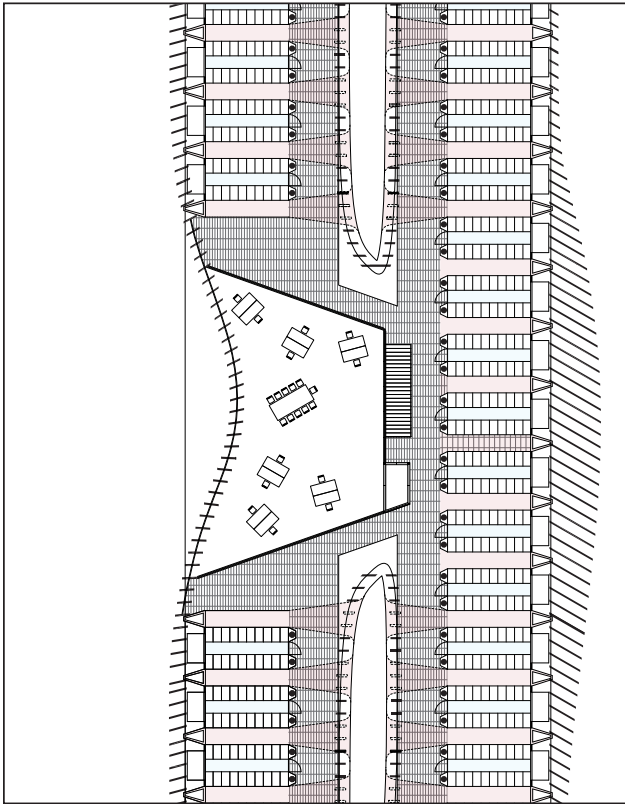


Figure 42
Detailed Plan / Level 6

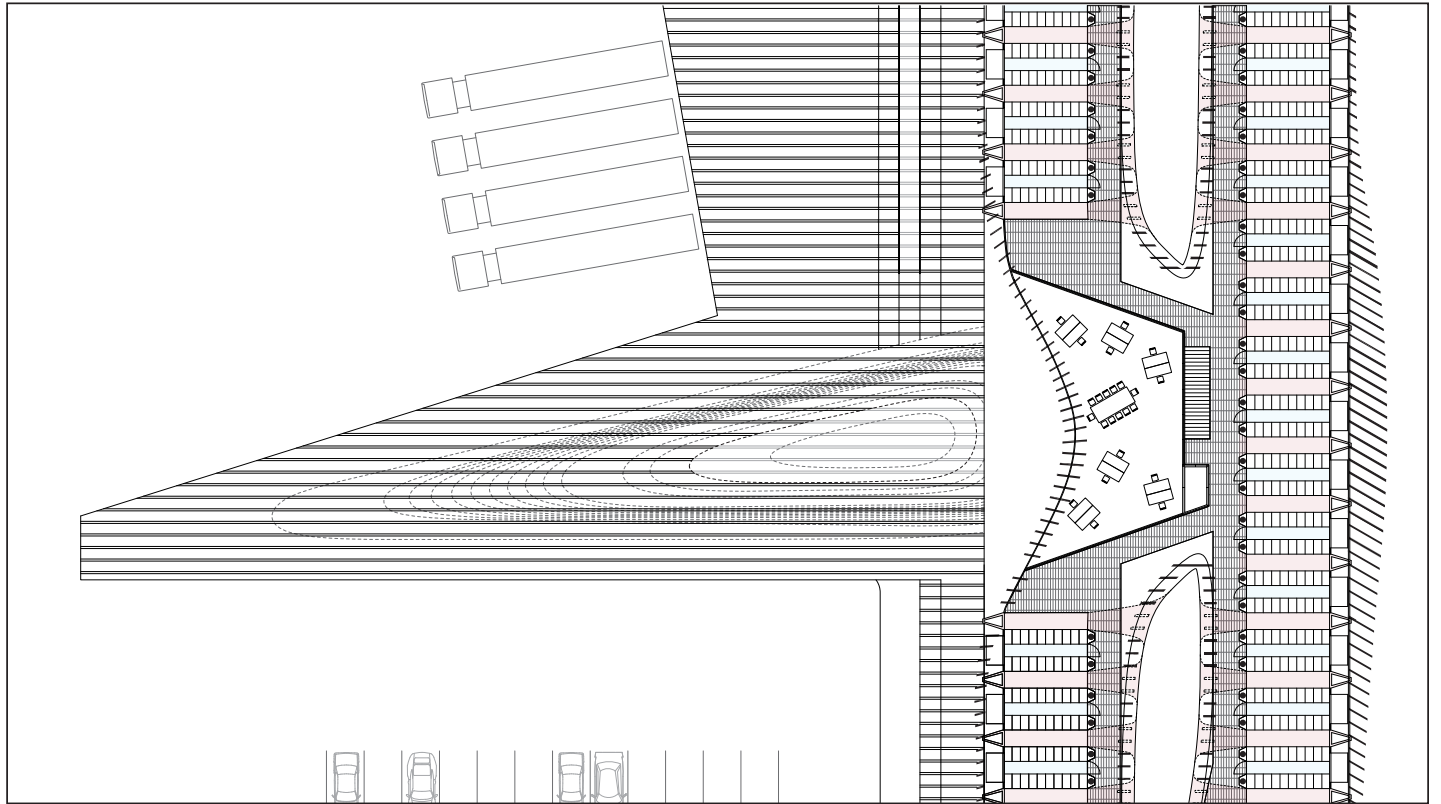


Figure 43
Detailed Plan / Level 3

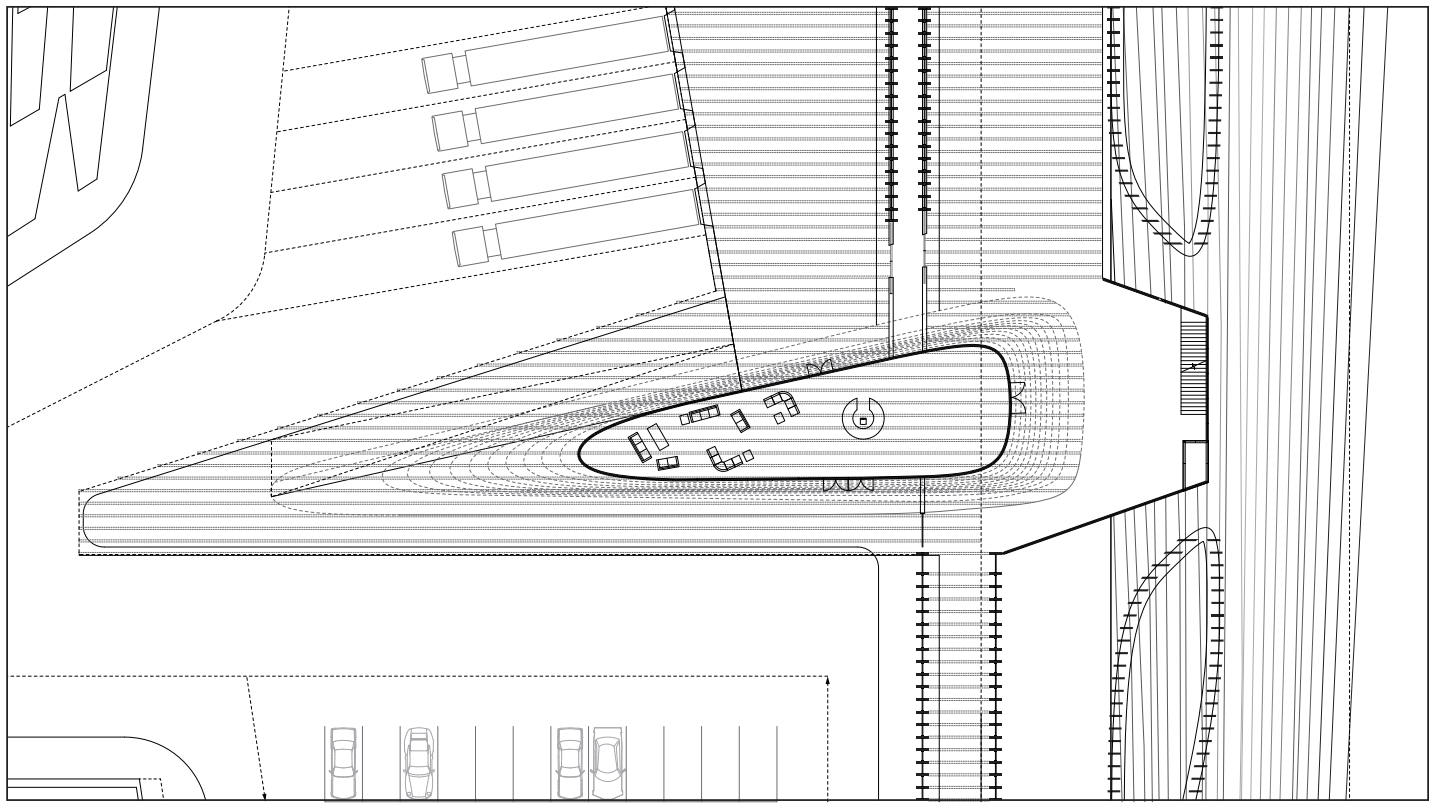


Figure 44
Detailed Plan / Ground level

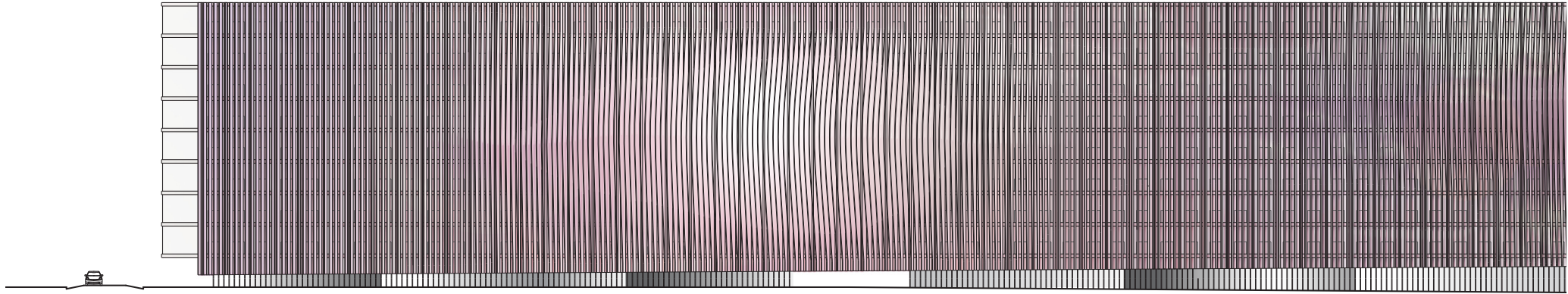


Figure 45
East Elevation / Morning

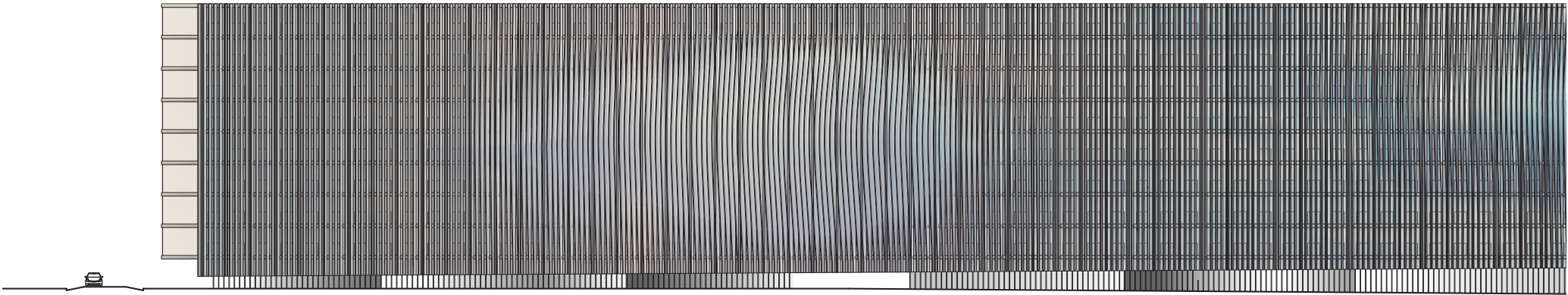
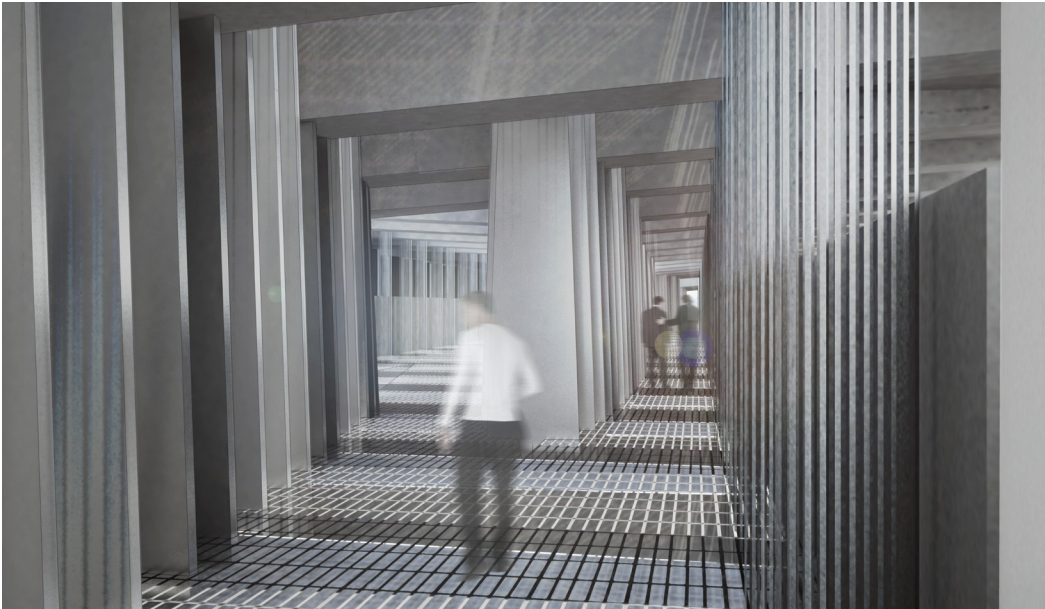


Figure 46
East Elevation / Afternoon

Figure 47-48
Interior Renderings



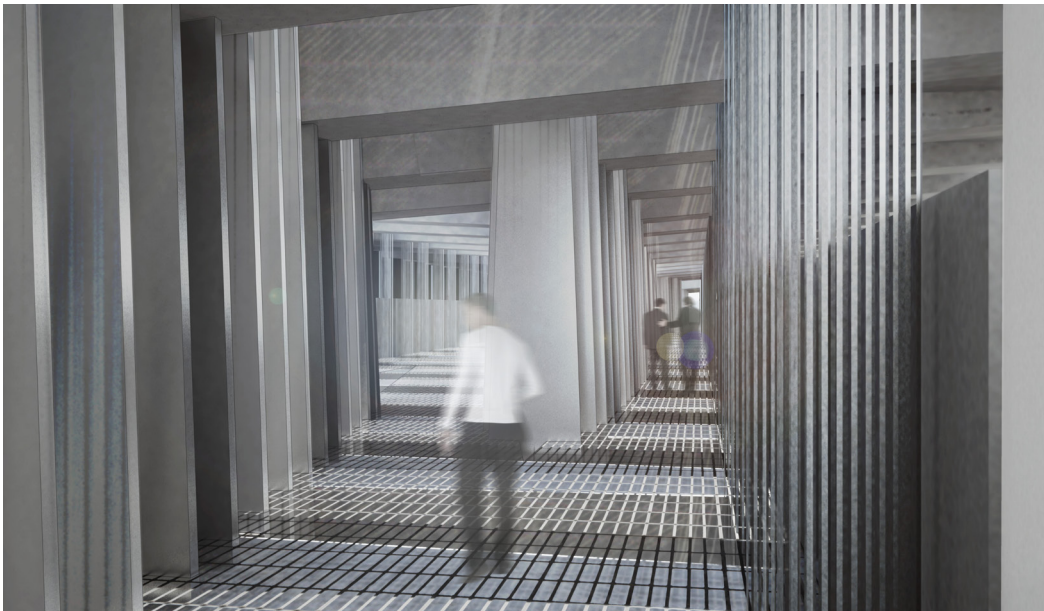
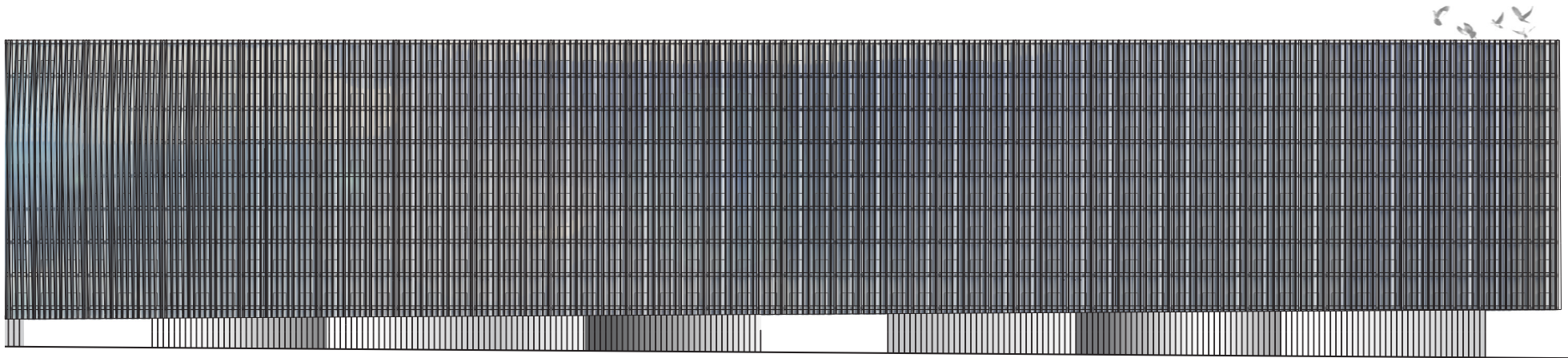
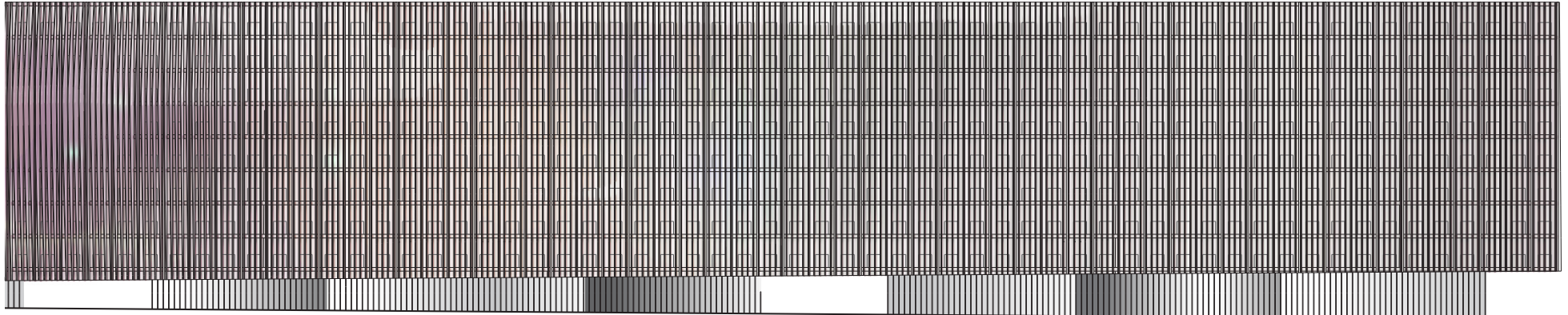
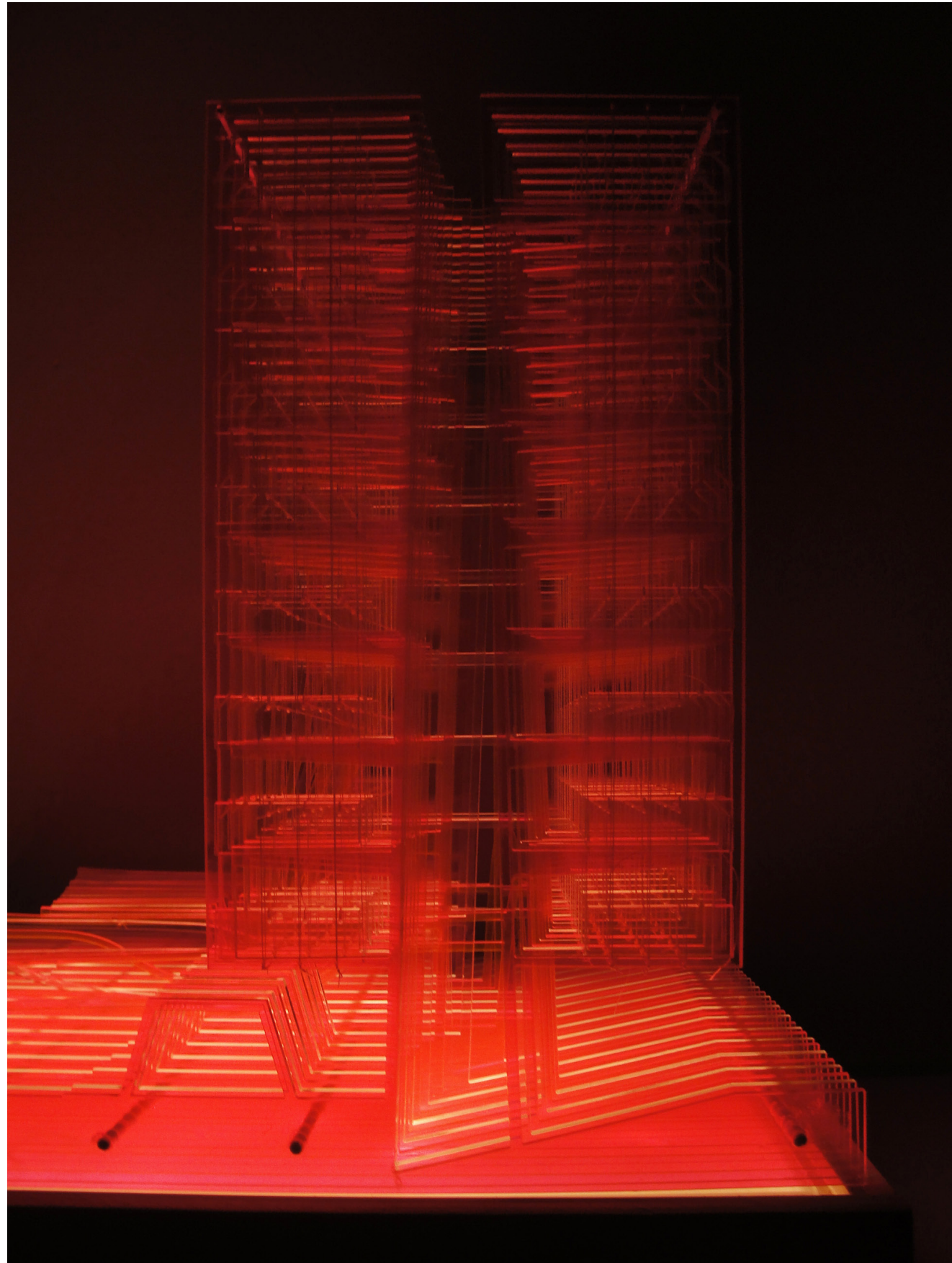


Figure 49
Physical model photo



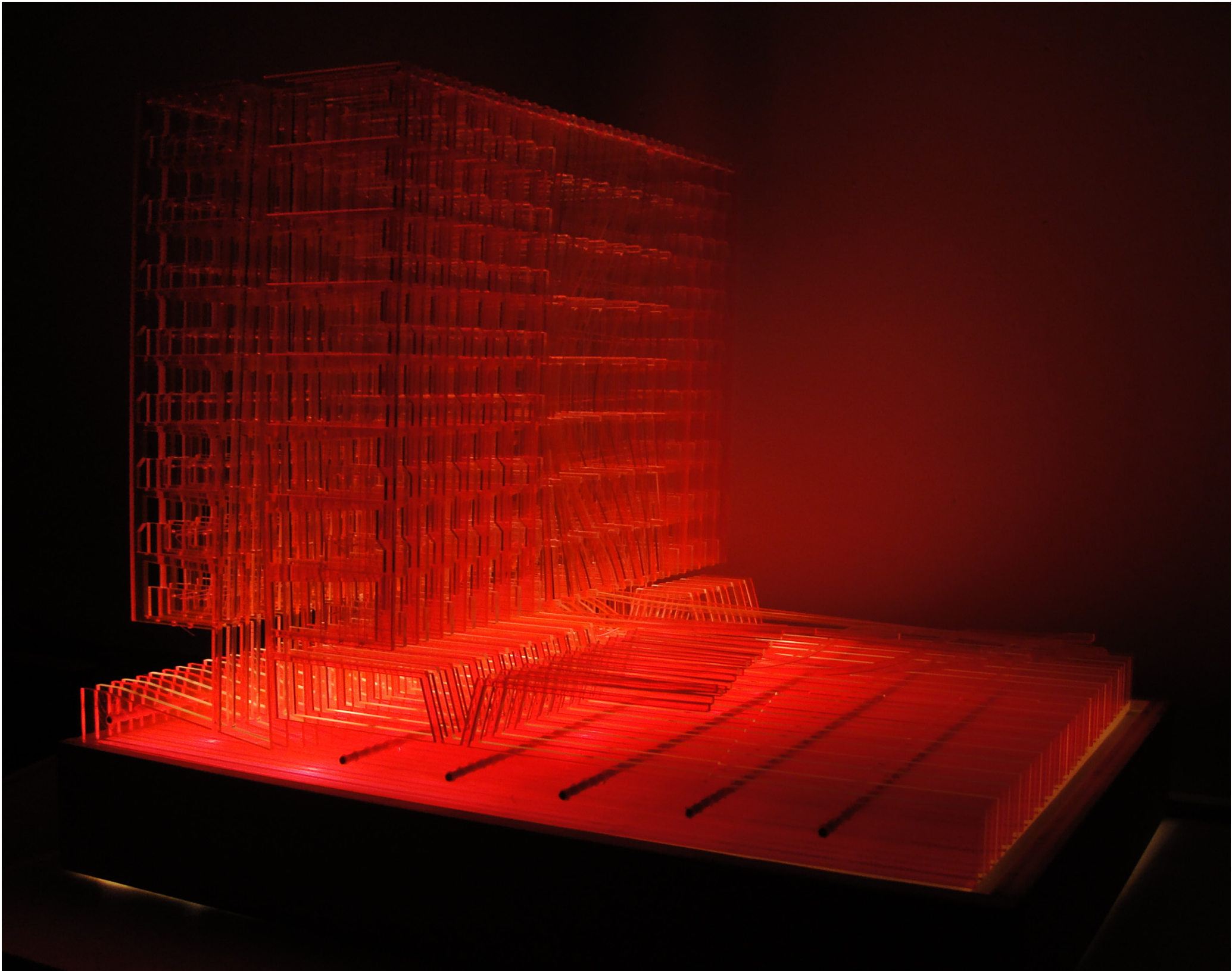


Figure 50
Physical model photo



Figure 51
Exterior Rendering



Figure 52
Exterior Rendering

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